MICRONTA®

20,000 OHMS/VOLT FOLDING MULTITESTER INSTRUCTION MANUAL

OHMS
20,000Ω/V DC
10,000Ω/V AC
OHMS ADJUST
OUTPUT
+DC 1000V
AC 1000V
COM
AC V

CAT.NO.22-211

CUSTOM MANUFACTURED FOR

RADIO SHACK, A DIVISION OF TANDY CORPORATION

INTRODUCTION

This compact, sensitive Multitester is designed to measure AC and DC voltages, DC current, and resistance with accuracy and ease.

The single knob function control is easy to read and use. The 4" (10 cm) meter incorporates a mirrored scale for accurate readings and uses three colors for rapid scale identification.

The meter movement is shunted, for protection, during transit. This is accomplished automatically every time the Multitester is folded shut.

The meter circuit incorporates a fuse to protect the delicate meter movement and other internal parts in case of inadvertent overload or improper function selection.

The operating and indicating sections are connected to each other by a hinge-joint with detent. This allows the user to get an optimum angle for easy reading in all operating positions either when portable or on bench top.

44" (110 cm) well insulated test leads with banana-type plugs result in firm, safe, low-resistance circuit connections.

Small and light, this instrument will provide many years of accurate voltage, current, and resistance measurements. One AA cell provides power for resistance measurement.

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SPECIFICATIONS

Ranges:	25
DC Voltage	0-0.6-3-15-60-300-600-1200V
AC Voltage	0-15-60-150-600-1200V
DC Current	0-60 μA-3-30-300 mA
Resistance	0-2K, 0-20K, 0-200K, 0-2Meg. (center scale 24)
Decibels	−20 to +63 dB in 5 ranges
Output	0-15-60-150-600V
Accuracy (at horizontal position):	±3% of full-scale, DC voltage and current ±4% of full-scale, AC voltage ±3% of scale-length, Resistance
Influence of Scale Angle (at vertical position):	±2% of full scale
Sensitivity:	20,000 ohms/volt DC 10,000 ohms/volt AC
Meter Movement:	4″ (10 cm), 3-color, mirrored scale, 37 μA movement
Detent:	90, 120, 150, 180 degrees
Battery:	Requires one type AA penlight cell for ohms function
Leads:	44″ (110 cm) banana-plug style
Fuse:	0.5A, 250V fast-acting, 5x20 mm type
Size:	7.3H x 4.4W x 1.3D inches 18.4H x 11.0W x 3.3D cm (fully open) 4H x 4.4W x 2.5D inches 10.0H x 11.0W x 6.3D cm (fully closed)
Weight:	350 g (0.8 lbs.)

TO USE

The following special markings are designed to remind you of safety.

⚠ Refer to the following operating instructions.

⏚ To avoid electrical shock and/or instrument damage do not connect the common input terminal (—jack) to any source of more than 500 volts with respect to earth/ground.

Press latch on the front of case to open.

Remove battery cover and install one AA cell (not supplied). We recommend our 23-582 or 23-552. Be sure to observe proper polarity. Close the cover.

When you can't adjust the pointer to "0" on OHMS range, it's time for a new battery. Never leave a weak or dead battery in your unit. Even a "leak-proof" battery may leak damaging chemicals. Also, if you are not going to use your unit for a week or more, remove the battery.

Notes: For most accurate readings, keep the meter lying flat on a non-metallic surface. Use a range setting that results in a reading in the upper 1/3rd of the meter scale.

Also, look at the scale from the point where the pointer and its mirror reflection come together; otherwise your reading will be inaccurate due to parallax.

The pointer may shift slightly from the "0" position as you change the angle of the meter section.

If the pointer does not normally rest exactly over the "0" at the left side of the scale, adjust the plastic screw in the lower center of the meter face to bring the needle to "0."

Always observe correct test lead polarity when making DC voltage and current measurements (Black into the ⊖ COM and Red into the ⊕ V-Ω-A or DC600V or DC1200V jacks).

> **CAUTION:** THE MAXIMUM INPUT LIMIT FOR VOLTAGE AND CURRENT MEASUREMENT BETWEEN ⊕ V-Ω-A AND ⊖ COM IS 600V AC, 300V DC AND 300mA DC.

TEST LEADS

Use only the same type of test leads as those supplied with your unit. These test leads are rated for 1200 volts; replacements are available from your local Radio Shack store.

DC VOLTAGE MEASUREMENTS

> **WARNING** ⚡ USE EXTREME CARE WHEN MAKING MEASUREMENTS FOR HIGH VOLTAGE; DO NOT TOUCH TERMINALS OR PROBE ENDS.

1. Plug the test leads into the correct jacks (Black into ⊖ COM and Red into ⊕ V-Ω-A).
2. Set the range switch to one of the DCV positions; it is best to start at the top and work down.

   If you're uncertain about voltage level, start with 1200V range as noted in step 5.

3. Touch the test probe tips to the circuit under test; be sure to observe correct polarity.
4. Read the voltage on the black DC scales.
5. For voltages between 300 and 600, set the range switch to 300&UP and plug the red test lead into the DC600V jack. For voltages between 600 and 1200, leave the range at 300&UP and plug the red test lead into the DC1200V jack.

   USE EXTREME CARE WHEN USING THESE RANGES.

AC VOLTAGE MEASUREMENTS

> **WARNING** ⚡ USE EXTREME CARE WHEN MAKING MEASUREMENTS FOR HIGH VOLTAGE; DO NOT TOUCH TERMINALS OR PROBE ENDS.

1. Plug the test leads into the correct jacks.
2. Set the range switch to one of the ACV positions. (It is best to start at the top and work down.)

   If you're uncertain about voltage level, start with 1200V range as noted in step 5.
3. Touch the test probe tips to the circuit under test.
4. Read the voltage on the red AC scales.
5. For voltages between 600 and 1200, set the range switch to 600&UP and plug the red test lead into the AC1200V jack.

RESISTANCE MEASUREMENTS

Before taking any resistance measurements, disconnect the power to the unit under test and discharge the capacitors. It is best to remove batteries and unplug line cords.

> **WARNING** ⚡ DO NOT APPLY VOLTAGE TO MEASURING TERMINAL WHILE RANGE SWITCH IS IN OHM POSITION.

1. Plug the test leads into the ⊖ COM and ⊕ V-Ω-A jacks.
2. Set the range switch to one of the OHMS positions; touch the test probe tips together and adjust the OHM ADJUST control to bring the pointer to the "0" on the top (green) OHMS scale.
3. Now, touch the probe tips across the circuit or part under test.
4. Read the resistance on the green OHMS scale; use the proper multiplier to obtain the correct value (R times 1, 10, 100, or 1000, depending on the position of the range switch).

Notes: When you are unable to adjust the pointer to "0" on the OHMS scale, the battery must be replaced. When measuring resistance, it is best to disconnect one side of the part under test. (The remainder of the circuit will not interfere with the readings.)

Note for Testing Semiconductor Junctions: When attempting to identify cathode and anode ends or the type of transistor (PNP or NPN), the actual polarity of the tester's voltage is opposite of the lead colors. The red lead is the negative source. The black lead is positive.

DC CURRENT MEASUREMENTS

WARNING ϟ DO NOT APPLY VOLTAGE TO MEASURING TERMINAL WHILE RANGE SWITCH IS IN CURRENT POSITION.

1. Plug the test leads into the correct jacks.
2. Set the range switch to the 300m DCA position (300 milliamp). Always start at the top and work down.
3. Open up the circuit in which you want to measure the current and connect the black lead to the negative side and the red lead to the positive side of the circuit.
4. Apply power to the circuit under test and read the current on the black DC scales.

DECIBEL MEASUREMENTS

1. Plug the test leads into the correct jacks.
2. Set the range switch to one of the ACV ranges.
3. For a range switch setting of 15 ACV, read dB directly on the bottom scale in dB. For other settings of the range switch, add the appropriate number of dB to the dB scale reading as noted on the chart at the lower right on the meter face.

Note: For absolute dB measurements, circuit impedance must be 600 ohms. 0 dB = 1 milliwatt dissipated in a 600 ohm impedance (equivalent to 0.775 volts across 600 ohms).

OUTPUT VOLTAGE MEASUREMENTS

1. To measure AC voltage in the presence of DC voltage, use the output function. Connect the black lead to the ⊖ COM jack and the red lead to the OUTPUT jack.
2. Set the range switch to an ACV position and measure the voltage in the circuit.

Note: The output function incorporates a DC blocking capacitor, rated at 600 volts. Do not exceed the 600 volt rating when measuring output voltages.

3. Read output voltages on the same scales as for AC voltage.

REPLACEMENT OF BATTERY/FUSE

WARNING ϟ TO AVOID ELECTRIC SHOCK, DISCONNECT MEASURING TERMINALS BEFORE REMOVING BATTERY OR FUSE. REPLACE ONLY WITH SAME TYPE BATTERY OR FUSE. THIS INSTRUMENT CONTAINS NO USER SERVICEABLE PARTS.

SCREW REMOVAL BY QUALIFIED PERSONS ONLY.

CAUTION: FOR CONTINUED PROTECTION AGAINST FIRE, REPLACE ONLY WITH 0.5A, 250V FUSE.

NOTE:

The fuse used in your Multitester is a special size and type. Replacement fuses may be obtained from your local Radio Shack store.

1. Disconnect the test leads.
2. Open the battery/fuse compartment cover.
3. Pull the red ribbon in the fuse compartment. The fuse will pop out.
4. Insert a new fuse on the ribbon ring. Use only a fuse of the same type/rating (0.5A, 250V. Radio Shack Cat. No. 270-1241).
5. Install the fuse with ribbon in the fuse compartment.
6. Close the battery/fuse compartment cover.
7. Space is provided in the battery/fuse compartment for a spare fuse. It pays to carry spares!

> **WARNING ⚡** DO NOT OPERATE YOUR UNIT UNTIL THE BATTERY/FUSE COVER IS IN PLACE AND FULLY CLOSED.

GOOD METER MEASUREMENT PRACTICES

Here are some good general rules that apply to the use of electrical meters. Some are common-sense, some are safety precautions, and some are just plain good habits to get into.

1. **CAUTION:** There is always the possibility of dangerous voltage being present in any piece of electrical/electronic equipment. Always use extreme caution when making measurements— high voltage may appear at unexpected points in a suspected defective circuit.
2. When making measurements, never stand on a wet or damp floor. Do not work near (or on) any grounded metal object — for example, a metal work table, metal water or gas pipes, metal electrical conduit. Accidental contact between the grounded metal object and the circuit under test can be lethal.
3. Always use only well-insulated test leads. Never use test leads without insulated test prods. Never allow your fingers to touch the bare metal part of the test probes (or circuit points).
4. Never use test leads with frayed or broken insulation; voltages will appear at all exposed contact points on the leads.
5. Never attempt to measure voltages or currents above the specified maximum the meter is designed for; refer to the specifications section.

6. For safety's sake, disconnect leads as soon as you've completed measurements.
7. Always turn off the unit's power before connecting test leads. This is especially true when working on circuits with 100 or more volts.
8. Get into the habit of keeping one hand in your pocket when trouble-shooting any equipment containing high voltage circuitry. Using only one hand decreases the chance of electric shock.
9. You should remember that even a small shock can be dangerous, for your body's reaction to a minor shock can cause you to bump or fall against a higher-voltage contact.
10. Discharge filter capacitors before connecting test leads: such capacitors can retain hazardous charges in units with high voltage circuits.
11. When making voltage and current measurements always start with the highest range available.
12. Never attempt to measure a voltage when the function is set to resistance or current. (It may burn out the meter movement or other circuitry.) Never attempt to measure current with the meter set for resistance.
13. Never attempt to measure AC voltages or current with the meter set to a DC mode. (Meter circuitry can be damaged.)

14. Do not attempt to measure RF voltages with the meter. (It can be damaged or, at best, the readings will be meaningless.)

15. Do not expose your meter to moisture; avoid high humidity and excessive dust and dirt.

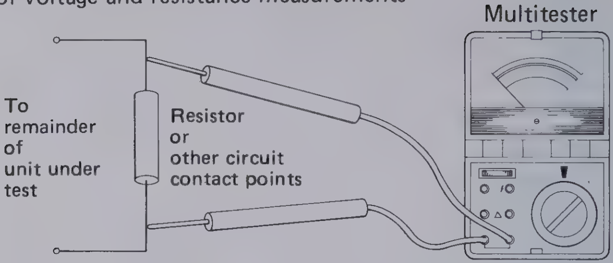
16. Avoid vibration or mechanical shock; the Meter might be damaged or its accuracy affected.

17. Avoid using meters in locations with high magnetic fields. (Inaccurate measurements can result.)

18. Remember that voltage and resistance measurements are made with the Meter connected in parallel. Current measurements are made with the meter connected in series.

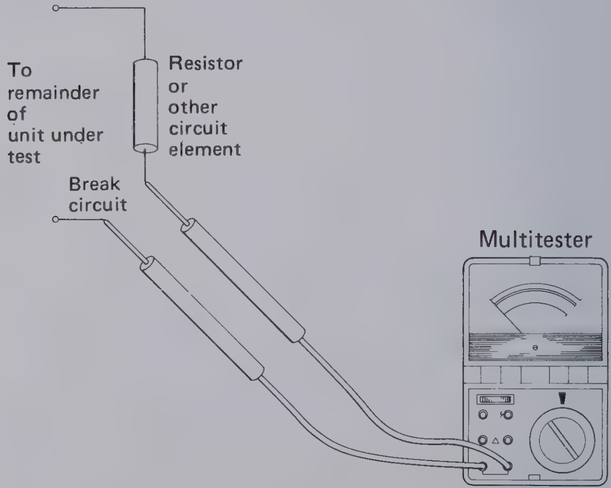
PARALLEL METER CONNECTION

For voltage and resistance measurements


Multitester
To remainder of unit under test
Resistor or other circuit contact points

SERIES METER CONNECTION

For current measurements


To remainder of unit under test
Resistor or other circuit element
Break circuit
Multitester

RADIO SHACK LIMITED WARRANTY

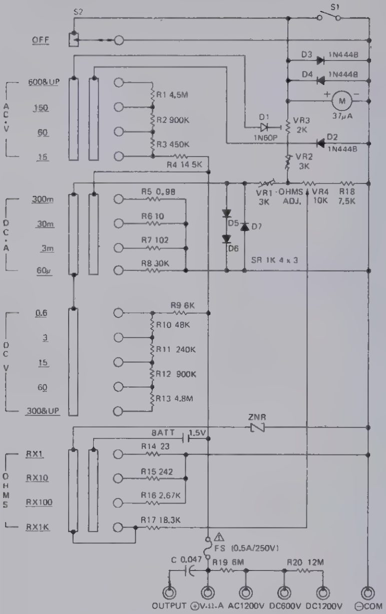
This product is warranted against defects for 90 days from date of purchase from Radio Shack company-owned stores and authorized Radio Shack franchisees and dealers. Within this period, we will repair it without charge for parts and labor. Simply **bring your Radio Shack sales slip** as proof of purchase date to any Radio Shack store. Warranty does not cover transportation costs. Nor does it cover a product subjected to misuse or accidental damage.

EXCEPT AS PROVIDED HEREIN, RADIO SHACK MAKES NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Some states do not permit limitation or exclusion of implied warranties; therefore, the aforesaid limitation(s) or exclusion(s) may not apply to the purchaser.

This warranty gives you specific legal rights and you may also have other rights which vary from state to state

We Service What We Sell

SCHEMATIC DIAGRAM


S2
S1
OFF
D3 1N4448
D4 1N4448
M 37μA
+
−
A C • V
600&UP
150
60
15
R1 4.5M
R2 900K
R3 450K
R4 14.5K
D1 1N60P
VR3 2K
D2 1N4448
VR2 3K
VR1 3K
OHMS ADJ.
VR4 10K
R18 7.5K
D C • A
300m
30m
3m
60μ
R5 0.98
R6 10
R7 102
R8 30K
D5
D6
D7
SR 1K 4 x 3
D C V
0.6
3
15
60
300&UP
R9 6K
R10 48K
R11 240K
R12 900K
R13 4.8M
ZNR
BATT 1.5V
O H M S
RX1
RX10
RX100
RX1K
R14 23
R15 242
R16 2.67K
R17 18.3K
⚠
FS (0.5A/250V)
C 0.047
R19 6M
R20 12M
OUTPUT
⊕V-Ω-A
AC1200V
DC600V
DC1200V
⊖COM

NOTES: (1) ALL RESISTANCE VALUES ARE INDICATED IN "OHM." (K = 10^3 OHM. M = 10^6 OHM.)
(2) CAPACITANCE VALUE IS INDICATED IN "μF."

CAUTION: COMPONENTS MARKED WITH ⚠ ARE CRITICAL FOR SAFETY.

Schematic subject to change without notice.
For most accurate Schematic (and parts) contact Radio Shack, National Parts Dept., Fort Worth TX 76101
In UK, contact Tandy Electronics, National Parts Dept., Bilston Road, Wednesbury, West Midlands WS10 7JN.
In Australia, contact Tandy Australia Limited, National Parts Dept., 91 Kurrajong Avenue Mount Druitt, N.S.W. 2770

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CANADA: BARRIE, ONTARIO L4M 4W5

TANDY CORPORATION

AUSTRALIA	BELGIUM	U.K.
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10A4 **Printed in Korea**

GOOD METER MEASUREMENT PRACTICES

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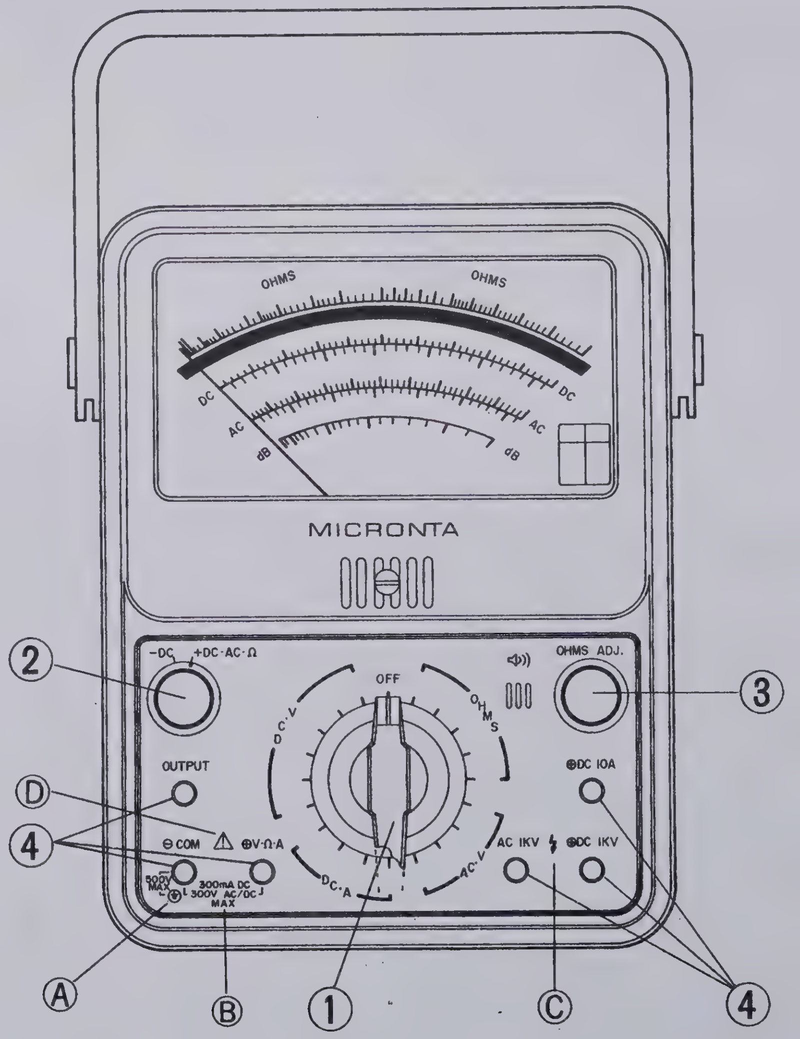
3. Always use only well insulated test leads. Never use test leads without insulated test prods. Never allow your fingers to touch the bare metal part of the test probes (or circuit points).
4. Never use test leads with frayed or broken insulation; voltages will appear at all exposed contact points on the leads.
5. Never attempt to measure voltages or currents above the specified maximum the meter is designed for; refer to Specifications section (Page 3).
6. For safety's sake, disconnect leads as soon as you've completed measurements.
7. Always turn off the unit's power before connecting test leads. This is especially true when working on circuits with 100 or more volts.



DECIBEL MEASUREMENTS

1. Plug the test leads into the proper jacks — Black into ⊖ **COM** and Red into ⊕ **V-Ω-A**.
2. Set Range Switch to one of the **ACV** positions; use a range that provides a meter reading in the upper 1/2 of the meter scale.
3. Read dB on the dB scale, adding the appropriate number of dB to the dB scale reading as noted in the chart at the lower right of the meter face.

NOTE: For absolute dB measurements, circuit impedance must be 600 ohms. 0 dB = 1 milliwatt dissipated in a 600 ohm impedance (equivalent to 0.775 volts across 600 ohms).

OUTPUT VOLTAGE MEASUREMENT

1. To measure AC voltage in the presence of DC voltage, use the OUTPUT function. Connect the Black lead to the ⊖ **COM** jack and the Red lead to the **OUTPUT** jack.
2. Set Function switch to **+DC·AC·Ω** position.
3. Set the Range switch to an **AC V** position and measure the voltage in the circuit.

NOTE: The function incorporates a DC blocking capacitor, rated at 600 volts.
Thus, do not exceed the 600 volts rating when measuring output voltage.

4. Read output voltages on the same scale as for AC voltage.

REPLACEMENT OF BATTERY/FU

WARNING: TO AVOID ELECTRIC SHO
CONNECT MEASURING TERMINALS
REMOVING BATTERY OR FUSE. R
ONLY WITH SAME TYPE BATTERY O
THIS INSTRUMENT CONTAINS NO USE
ICEABLE PARTS.
SCREW REMOVAL BY QUALIFIED
ONLY.
CAUTION: FOR CONTINUED PROTEC
GAINST FIRE, REPLACE ONLY WITH 0.
FUSE.

To install or replace the Batteries/Fuse, l
screw on Battery/Fuse Compartment Cover

NOTE: The fuse will blow when voltage is
resistance or current mode. In this case there
meter movement (Replace the fuse).

1. Disconnect the test leads.
2. Open the Battery/Fuse Compartment Cove
3. Pull the red ribbon in the Fuse Compartr
fuse will pop out.
4. Insert a new fuse on the ribbon ring. Use
of the same type/rating (0.5A, 250V).
5. Install fuse with ribbon in the Fuse Compar
6. Close the Battery/Fuse Compartment Cover

WARNING: DO NOT OPERATE THE UN
THE BATTERY COVER IS IN PLACE AND
CLOSED.

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3. Always use only well insulated test leads. Never use test leads without insulated test prods. Never allow your fingers to touch the bare metal part of the test probes (or circuit points).

4. Never use test leads with frayed or broken insulation; voltages will appear at all exposed contact points on the leads.

5. Never attempt to measure voltages or currents above the specified maximum the meter is designed for; refer to Specifications section (Page 3).

6. For safety's sake, disconnect leads as soon as you've completed measurements.

7. Always turn off the unit's power before connecting test leads. This is especially true when working on circuits with 100 or more volts.

8. Get into the habit of keeping one hand in your pocket when trouble-shooting any equipment containing high voltage circuitry.

9. You should remember that even a small shock can be dangerous, for your body's reaction to a minor shock can cause you to bump or fall against a higher voltage contact.

10. Discharge filter capacitors before connecting test leads; such capacitors can retain hazardous charges in units with high voltage circuits.

11. When making voltage and current measurements always start with the highest range available.

12. Never attempt to measure a voltage when the function is set to resistance or current (it may burn out the meter movement or other circuitry). Never attempt to measure current with the meter set for resistance.

13. Never attempt to measure AC voltages or current with the meter set to a DC mode (meter circuitry can be damaged).

14. Do not attempt to measure RF voltages with the Meter (it can be damaged, or at best the readings will be meaningless).

15. Do not expose your meter to moisture; avoid high humidity and excessive dust and dirt.

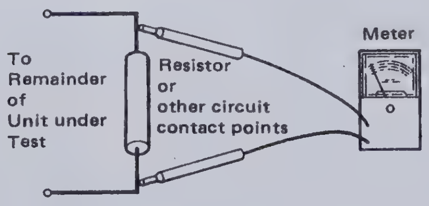
16. Avoid vibration or mechnical shock; the meter might be damaged or its accuracy affected.

17. Avoid using meters in locations with high magnetic fields (inaccurate measurements can result).

18. Remember that voltage and resistance measurements are made with the Meter connected in parallel. Current measurements are made with the meter connected in series.

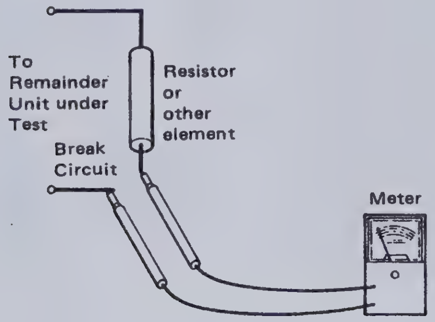
PARALLEL METER CONNECTION

For Voltage and Resistance measurements

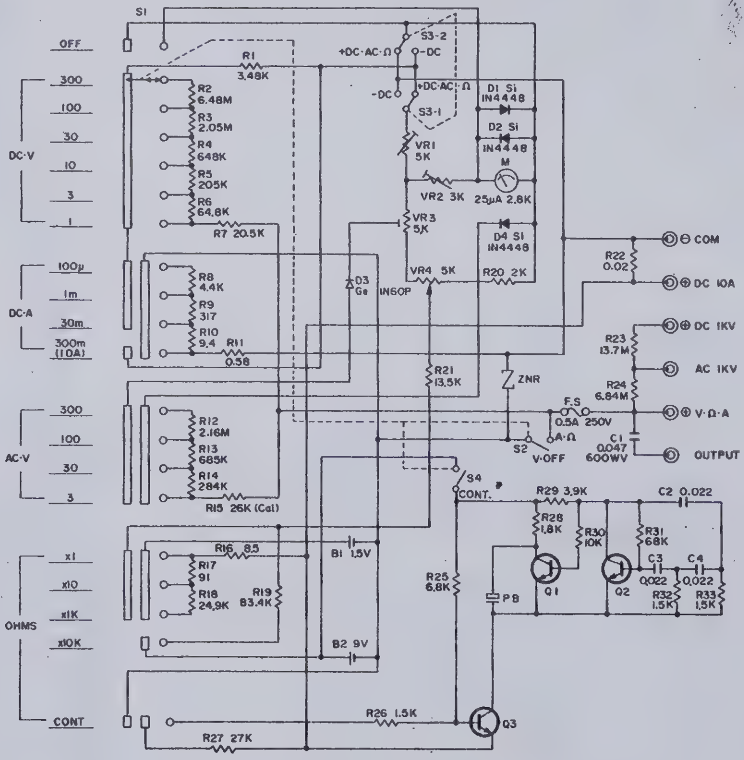

Meter
To Remainder of Unit under Test
Resistor or other circuit contact points

SERIES METER CONNECTION

For Current measurements


To Remainder Unit under Test
Break Circuit
Resistor or other element
Meter

SCHEMATIC DIAGRAM


S1
OFF
DC·V
300
100
30
10
3
1
DC·A
100μ
1m
30m
300m (10A)
AC·V
300
100
30
3
OHMS
x1
x10
x1K
x10K
CONT
R1 3.48K
R2 6.48M
R3 2.05M
R4 648K
R5 205K
R6 64.8K
R7 20.5K
R8 4.4K
R9 317
R10 9.4
R11 0.58
R12 2.16M
R13 685K
R14 284K
R15 26K (Cal)
R16 8.5
R17 91
R18 24.9K
R19 83.4K
B1 1.5V
B2 9V
R27 27K
R26 1.5K
Q3
D3 Ge IN60P
S3-2
S3-1
+DC·AC·Ω
-DC
VR1 5K
VR2 3K
VR3 5K
VR4 5K
D1 Si IN4448
D2 Si IN4448
M 25μA 2.8K
D4 Si IN4448
R20 2K
R21 13.5K
ZNR
F.S 0.5A 250V
A·Ω
S2 V·OFF
S4 CONT.
R25 6.8K
PB
R28 1.8K
R29 3.9K
R30 10K
R31 68K
Q1
Q2
C3 0.022
C4 0.022
R32 1.5K
R33 1.5K
C2 0.022
R22 0.02
R23 13.7M
R24 6.84M
C1 0.047 600WV
⊖ COM
⊕ DC 10A
⊕ DC 1KV
AC 1KV
⊕ V·Ω·A
OUTPUT

Q1, 2, 3 :
2SC1815 (Y, GR) or
2SC536 (F, G, H) or
KTN5014 (Y, GR, BL) or
MPS9532 (I, J, K, L)

NOTE
(1) ALL RESISTANCE VALUES ARE INDICATED IN "OHM" ($K=10^3$ OHM $M=10^6$ OHM)
(2) ALL CAPACITANCE VALUES ARE INDICATED IN "μF"

TC 162
MIGHTY MITE VII
TUBE TESTER
SERVICE MANUAL

SENCORE
SHORTS
METER ZERO
MIGHTY MITE VII
TC162 TUBE TESTER
RESET
PIN ELIMINATION
FUNCTION
SHORTS
FILAMENT
LOAD
SETUP

SENCORE
"the all american line"

SAFETY PRECAUTIONS

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. An isolation transformer should always be used on equipment having the chassis tied to one side of the AC power line.
2. When making test lead connections to high voltage points, remove the power, if this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.
3. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.
4. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.
5. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.
6. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with high voltages.

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INSTRUCTION MANUAL FOR THE SENCORE TC162 MIGHTY MITE VII TUBE TESTER

DESCRIPTION

New receiving tubes for the television and electronic industry have been introduced at a very rapid rate, even with transistors making great strides. These tubes now contain many more internal connections that require isolation before testing. The Sencore engineering staff has kept pace with this increase and change in technology on the Mighty Mite by adding an all new pin elimination system. This enables the Mighty Mite to check more tubes than ever before. The new Mighty Mite still uses the tests that have made the Mighty Mite the standard in tube testing. Here are the features of the Mighty Mite:

* Full load cathode current check to pick out the weak tubes other testers might miss.

* 100 megohms grid leakage sensitivity to find the tough dog tubes fast.

* Stethoscopic shorts test of 300K to pick out true shorts in the tube.

* Pin elimination switches for faster isolation and elimination of false shorts.

* Burn out proof meter, even if a shorted tube is tested.

* FET balanced bridge circuitry for instant on action and greater accuracy.

* Steel and aluminum case for that professional look and maximum protection of the Mighty Mite for years of service.

SPECIFICATIONS

Cathode Emission Test: Full load current drawn through tube up to 120mA. Max applied voltage, 40 VAC RMS.

Grid Leakage Test: Good area, infinity to 200 megohms, ? area, 200 to 100 megohms and the Bad area 100 megohms or less.

Shorts Test: 300,000 ohms or less will cause shorts light to come on. Maximum applied voltage, 40 VAC RMS.

Power: 105 to 125 VAC, 50/60 Hertz at 32 watts maximum.

TESTS THE MIGHTY MITE WILL MAKE

Cathode Emission: The Mighty Mite tests all tubes at near their full rated cathode current level for the best emission check. This is very important as many testers do not test at this high level of current and can pass many tubes as good that will not work satisfactorily in the circuit. This test is very important on high power tubes such as rectifiers, horizontal and sound output tubes.

Grid Leakage Test: Grid leakage or grid emission in a tube can upset many circuits, including the AGC, Chroma, Video, Sync, and others. Grid currents as low as one microamp can change the bias in these circuits causing many headaches. The Mighty Mite detects grid currents as low as one-half a microamp or 100 megohms to pick out these trouble making tubes that are often missed by other tube checkers. As soon as the tube is warm enough to indicate cathode emission, the grid leakage test can be performed.

Shorts Test: The Sencore "Stethoscopic" shorts test picks out true shorts between elements in the tube of 300,000 ohms or less. Above this value, the shorts light may flicker indicating a high resistance short in the tube. The applied voltage is kept below the 50 volt maximum to prevent possible damage to frame grid and nuvistor type tubes. This prevents the Mighty Mite from damaging tubes and introducing a short in the tube that was not there before. Pin elimination switches allow the isolation of extra pin connections on the different tube bases so that only a true short will show up on the shorts light.

OPERATION

ACQUAINTING YOURSELF WITH THE MIGHTY MITE

The Mighty Mite is extremely simple and easy to set up for tube testing. The A - PIN ELIMINATION switch, B - FILAMENT switch, C - LOAD switch, and D - SET UP switch are set according to the set up chart. The tube is inserted into the proper socket numbered one to thirteen as indicated in the set up chart and the desired function is selected by the FUNCTION switch and the results read on the meter or SHORTS light. No damage to the tester will result if a shorted tube is tested.

OPERATING THE MIGHTY MITE

The following is the basic operating procedure of the Mighty Mite. Each tube section is tested independently and the emission test is made for each section. The shorts test need be made only once for each tube.

1. Plug the Mighty Mite AC cord into a grounded three prong receptacle of 105 to 125 volts AC, 50 to 60 Hertz.

2. Locate the tube in the set up chart. The tubes are listed numerically and alphabetically. Looking to the right of the tube, note the set up

information for the controls, A, B, C, D and socket. Some tubes have more that one listing indicating the tube has more than one section to be tested. Each section of the multiple tube is tested seperately.

3. Push the PIN ELIMINATION switches listed under A down to eliminate those pins. If none are listed, leave all switches in the up position. Set the B, C and D switches to the positions indicated and insert the tube into the socket listed. Where more than one setting is listed, make the emission and grid leakage test on each section. The shorts test need be made only once.

4. Set the Function switch to SHORTS and check the front panel METER ZERO adjust for a O indication on the meter. Rotate the "D" switch slowly through all its positions noting the SHORTS light on the front panel. The light will glow if a short of 300K or less exists in the tube. In some tubes, a normal short will exist between the heater and cathode. These are noted in the set up chart by an asterisk(*). If the shorts light glows on the H-K position on these tubes, no short exists that will effect the operation of the tube. If the SHORTS light glows, then a short is present. If the short is present on two or more elements, then the tube should be rejected for shorts.

5. If the tube passes the SHORTS test, rotate the Function switch to the EMISSION position and read the emission quality of the tube on the top scale of the meter. A tube indicating in the questionable area (?), may or may not be rejected depending upon you and your customer.

6. If the tube reads in the GOOD area of the meter and passes the EMISSION test, switch to GRID LEAKAGE and read the grid leakage of the tube on the bottom scale of the meter. This is a very important check and will show up a lot of troublesome tubes that may otherwise check good. If the meter is indicating in the GOOD area of the meter but slowly rising, wait a minute or so to see if the meter will finally climb into the BAD area of the meter. On heavy power tubes, such as a horizontal output tube, do not make a grid leakage check after an extended emission check. If the tube is left in the emission check position for several minutes, the grid will heat up and when switched to grid leakage will read higher than normal. Allow the tube to cool slightly before the grid leakage check. You can expedite the grid leakage check by raising the filament voltage for a few seconds. This is not the same overheating as was caused in the emission check, but will show up grid leakage. If the grid leakage indication climbs into the BAD area on the meter, reduce the filament voltage and see if the meter remains in the bad area. If it does so, then the tube will give trouble in the circuit and should be replaced. If the meter drops off rapidly back into the GOOD area, then the tube is good.

If the tube passes all the above tests, it can be considered good and should not be replaced. If the tube is in the questionable area on any test, it is up to you or your customer to decide if the tube should be replaced. Show

your customer the action of the meter indication on the tube and explain what will happen. In this manner, the Mighty Mite becomes your customer convincer on new tube sales.

ADDITIONAL TESTS AND FUNCTIONS OF THE MIGHTY MITE

TUBE LIFE EXPECTANCY TEST

If the meter needle climbs very slowly into the GOOD area or Questionable area of the meter on the Emission test, the life expectancy of the tube can be considered much less than if the meter indicated GOOD in a shorter period of time. Also, if the needle should climb into the GOOD area and then "fall off", life expectancy can be considered much less. We can not recommend that you replace these tubes. That decision is up to you or your customer.

FILAMENT WARM UP TIME

When replacing a costly horizontal output tube in a television receiver, it is a good idea to not only check the horizontal oscillator for emission and other standard tests, but to also check the length of time it takes to warm up. If the horizontal oscillator tube is slower in warming up than the output tube, the output tube will draw heavy current and its life will be shortened considerable. Checking the warm up time of the oscillator tube and making sure that it is as fast or faster than the output tube can reduce the chance of a call back later for the same trouble and keep your customer's confidence high in your service ability.

LIFE TEST OR FILAMENT VOLTAGE SENSITIVITY

Some tubes may check good on the emission test and pass the other tests in the Mighty Mite, but still not operate properly in the receiver. These tubes may have a filament sensitive cathode. This means that the emission from the tube will change with a change in the applied filament voltage to the tube. This is caused from a low power line or defective power transformer in the receiver. These type of tubes can be most troublesome in series string receivers. To test for this trouble, simply push the LIFE TEST switch while monitoring the emission of the tube on the meter. A new tube will not change its reading at all while a filament sensitive tube will drop in emission. If the tube falls into the questionable area (?) on the meter, it will give trouble in the circuit and should be replaced. On a house call, be sure to show your customer the action and show how the tube checks on the Mighty Mite.

REJUVENATION

If you wish to rejuvenate a small tube, merely increase the filament voltage by setting switch "B" one setting higher for ten to fifteen seconds. This will super heat the cathode and boil out more emitting material from under the oxide coating. This is only a temporary measure as rejuvenation of a receiving tube will not last very long.

SETTING UP THE MIGHTY MITE FOR NEW TUBES

New tubes can sometimes be a problem as they may not be listed in the set up chart. This can be especially true on new receivers just introduced by the set manufacturers. With an understanding of the set up controls and what each does, you can set the Mighty Mite up from a tube manual or even the schematic of the receiver itself.

A PIN ELIMINATION

The A PIN ELIMINATION switch is used to isolate internal connections to the same pins or elements on the tube so that a test may be made. For example, the tube basing shown in figure 1 is a 9QL basing. The control grid is tied to pins 2 and 6, the screen grid to pins 1 and 7 and pin 9 is an internal connection that could be connected to any pin inside of the tube. To eliminate any shorts indication other than that which are true shorts in the tube, the A PIN ELIMINATION switches 6, 7, and 9 would be set in the down position to open these pins before the test is made. All the numbers correspond to the tube base pin number except for socket number 10, the compactron, pin 11 is connected to PIN ELIMINATION switch number 1. If no isolation is needed, all switches should be in the uppermost position. After each tube is tested, push the RESET switch to the left to place all switches in the up position. Each can be moved independently of each other, either up or down or set with the RESET switch.

B FILAMENT

This switch selects the filament voltage applied to the tube under test from 1 (one) to over 50 volts. The twelve position switch selects a range of voltage and with the unique design of the filament transformer, the tube under test will load the transformer to obtain the correct voltage for testing. When setting up a new tube, simply set the B FILAMENT switch to the correct voltage or voltage range.

C LOAD

This switch selects the proper AC voltage to be applied to the plate of the tube as well as the correct load resistor so that the tubes designed current can be set and the tube checked under full load. The current ranges for the settings of the C LOAD switch are as follows:

C LOAD switch	Cathode Current	C LOAD switch	Cathode Current
A	50 mA plus	F	2-7 mA
B	20-50 mA	G	.7-2 mA
C	15-30 mA	H	.5-.8 mA
D	10-16 mA	J	.5 mA or less
E	6-12 mA		

The current that the C LOAD switch is set to is the normal cathode current under normal bias conditions as listed in the tube manual. If a tube manual is not handy, then using Ohms law, compute the cathode current by the voltage drop across the cathode or plate load resistor in the circuit or from the schematic.

D SETUP

The "D" switch is used to pick up the control grid for the test on the tube. It was discovered many years ago, that approximately 97% of the electrons would go to the control grid when checking cathode emission so that this is now used as the pick-up element. In the example of Figure 1, the "D" switch would be set to one of the control grids that is not isolated. If pin 6 were to be isolated, then the "D" switch would be set to pick up pin 2.

The only exception to the above is on socket number 10 where pin 11 on the tube base is picked up with the first position of the "D" switch.

Sockets number 3 and 8 are wired identical except that socket number 8 has three pins not connected. This socket is used to isolate extra connections where more than two base pins are connected to the same element such as in the 1X2 high voltage rectifier. The seven pin sockets 4 and 7 are alike except that the filament pins on socket 4 are 3 and 4 while on socket 7 they are 1 and 7.

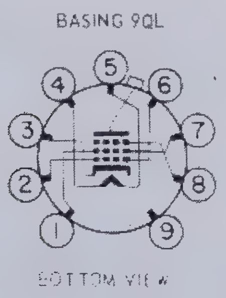
SOCKET SETUP

The sockets on the Mighty Mite have the filament pins prewired to eliminate the extra setup that is involved. The actual pin connections can be seen on the schematic diagram of the unit. Note that the two octal sockets have different filament connections. Socket number 1 is for filaments on pins 2 and 7 while socket number 2 is for filaments on pins 7 and 8. Sockets 3, and 8 have filaments on pins 4 and 5 while socket number 13 is for special Hi-Fi tubes with filaments on pins 1 and 2.

There are two novar sockets that are wired identical. Socket number 5 is for the standard novar based tubes while socket number 12 is for the magnoval based tubes. The pins on the magnoval based tubes are larger in diameter than the standard novar base and can damage the novar socket. All magnoval tubes are checked in socket number 12 to prevent damage to the regular novar socket number 5. When selecting the socket for a new tube, select the socket for the filament wiring as well as the socket the tube should fit into.

EXAMPLE OF SETTING UP THE MIGHTY MITE

Lets use for our example, the 6JE6 shown in Figure 1. This tube is a standard novar based tube with the control grid tied to two pins on the tube base.



TERMINAL CONNECTIONS

Pin 1 – Grid #2
Pin 2 – Grid #1
Pin 3 – Cathode
Pin 4 – Heater
Pin 5 – Heater
Pin 6 – Grid #1
Pin 7 – Grid #2
Pin 8 – Grid #3
Pin 9 – Internal connection – – do not use
Cap – Plate

Fig. 1 - 9QL Tube basing

FIRST: Determine the socket to use. In this case, the tube is a standard novar base tube so that socket number 5 will be used.

SECOND: All the pins that must be isolated for testing must be noted. In this example, we have the control grid on pins 2 and 6 and the screen grid on pins 1 and 7 with pin 9 possibly connected to some pin internally. With the A PIN ELIMINATION switch, we will isolate the extra pins. For our example, we will push switches 6 and 7 down or to the isolation position along with switch 9 to eliminate any possibility of this pin causing a false indication.

THIRD: Determine the filament voltage. In this case, it is the 6JE6 so that the filament switch "B" will be set to 6. The first set of numbers on the tube generally indicate the filament voltage of the tube. On foreign tubes, consult a substitution guide to find the filament voltage and characteristics that can be used to check the tube.

FOURTH: Select the current range that the tube is to be checked at using the information under "SETTING UP THE MIGHTY MITE FOR NEW TUBES", the C LOAD switch section. For our example, the A position would be used as the 6JE6 draws a very heavy plate current under normal use.

MAINTENANCE

DISASSEMBLY INSTRUCTIONS

To remove the Mighty Mite from its case for adjustment of the internal calibration control or for any repairs that may be necessary:

1. Remove the two screws at the top of the front panel.
2. Remove the two screws on the back of the case near the bottom of the unit.

The front panel should now be lifted from the case, exposing the internal circuits of the Mighty Mite for calibration or trouble shooting. To re-assemble the Mighty Mite, simply reverse the procedure.

CALIBRATION

The Mighty Mite should seldom change its calibration through its normal life. With the calibration module described below, you will not only be able to recalibrate the Mighty Mite, but periodically check its calibration and insure yourself of top performance. The module is constructed from an octal plug or an old octal tube base and is inserted into socket number one on the Mighty Mite. Figure 2 shows the schematic of the test module.

CR1 = Silicon Diode, 100PIV @ .5AMP
R1 = 100 Meg (4-22 MEG and
1-12 MEG in series)
R2 = 270K
R3 = 1K, 1%

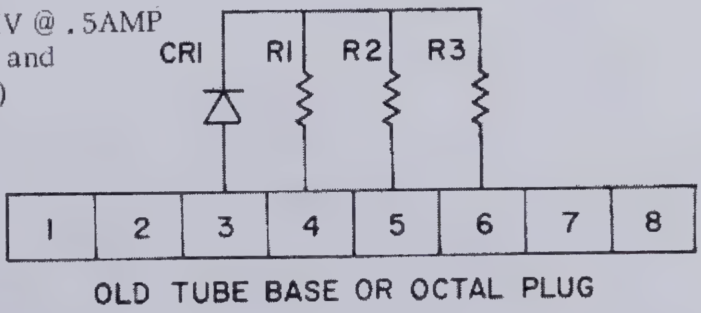


Figure 2. Cal Module Schematic

There are two calibration controls on the printed circuit board in the Mighty Mite. See Figure 3 for their location. The grid leakage must be set first and then the emission control. The grid leakage control is in series with the meter and will affect both emission and grid leakage calibration. Using the test module described above, plug it into socket number one and set the four front panel controls with the following settings.

	A	B	C	D	SKT
GRID LEAKAGE CALIBRATION	All Up	1	D	4	1

Set the FUNCTION switch to SHORTS and set the meter to zero with the METER ZERO control. Switch to GRID LEAKAGE and adjust R21, the Grid Leakage Cal Control until the meter reads on the line between ? and BAD on the Grid Leakage scale. Switch back to SHORTS and recheck the meter zero. To check and calibrate the Emission Cal control, use the following settings:

	A	B	C	D	SKT
Emission Calibration	All Up	1	D	3	1

Set the FUNCTION switch to SHORTS and recheck the meter zero. Switch to EMISSION and adjust R22, the Emission Cal control until the meter reads 60 on the Emission scale of the meter.

To check the shorts indicating circuit of the Mighty Mite, switch back to SHORTS and rotate the "D" switch through all its positions. Normal shorts should occur on positions 5 and 6.

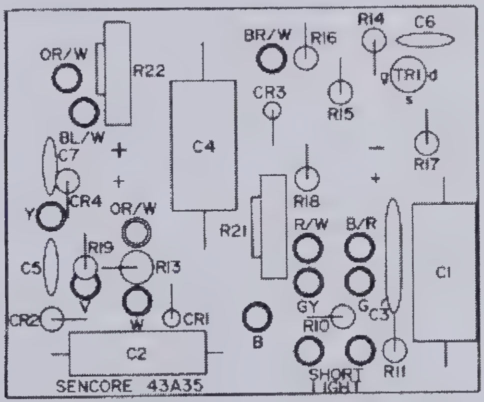


Fig. 3 - P.C. Board layout

CIRCUIT DESCRIPTION

The new Mighty Mite VII represents a unique breakthrough in tube checkers, being the first completely solid state tube checker. The new Mighty Mite uses the new FET or Field Effect transistor in place of the usual tube giving instant on action for faster and more accurate tube testing. Now, there is no need for the tube in the tester to warm up and stabilize before checking can begin and the change in calibration that goes along with the aging tube are also gone with the new solid state Mighty Mite.

The basic circuit of the Mighty Mite is a balanced bridge circuit meter amplifier consisting of FET TR1 and diode CR4. The zener diode represents a constant current source and takes the place of the second FET needed for the bridge circuit. The METER ZERO control on the front panel is just like the zero control of a VTVM and balances the circuit so with no signal input, the meter reads zero. When a voltage is impressed on the gate of the FET TR1, the bridge is unbalanced and the meter will read in proportion to the applied signal.

The cathode emission test puts an AC voltage between the control grid of the tube under test and the cathode with a load resistor in series to develop a pulsating DC voltage across. The C LOAD switch selects the different size load resistors and applied voltage so that a full range of current is available from less than .5 mA to 120 mA. The tube under test rectifies the applied AC voltage and develops across the load resistors R3 through R9. The pulsating DC voltage is coupled through the filter network of R22 and C7 to smooth it to a pure DC voltage. This voltage is applied to the gate of TR1 through an additional isolation and filtering network of R14, R15, R16 and C6. The resultant DC voltage upsets the balance of the circuit causing the meter to read upscale in proportion to the emission quality of the tube.

In the grid leakage test, the control grid of the tube under test is made negative to all other elements in the tube by connecting the grid to ground through the 30 megohm gate resistor consisting of R15 and R16, and applying a positive 8 volts to all other elements in the tube. If the tube has any grid leakage or contamination causing the tube grid to emit electrons, the flow of electrons will be through the gate resistor. Any current flow through the resistor will cause a voltage drop across the resistor causing an unbalance in the bridge circuit and the meter to read in proportion to the amount of grid current in the tube under test. A leakage of 100 megohms or less will cause the meter to read into the BAD area. A leakage of 100 to 200 megohms will cause a meter reading in the questionable area and a leakage of 200 megohms or more will read in the GOOD area on the meter. A leakage of 100 megohms represents a grid current in the tube under test of .5 microamps.

The shorts test uses the Sencore Stethoscopic approach where each and every element in the tube is checked against all other elements. A capacitor voltage divider of C1 and C2 is placed across the upper winding of the primary of the filament transformer. The AC voltage at this point is 75 volts and the capacitor C1 drops this to approximately 34 volts RMS that

is applied to nuvistors and frame grid tubes to prevent arc over and breakdown in these tubes. C3, a .1 capacitor is in series with the shorts test to prevent any DC action of the tube from lighting the shorts light. A true short will cause both elements of the neon bulb to light. If the short is 300,000 ohms or less, the shorts light will glow, but if the short is higher in resistance, the shorts light may only flicker.

The power supply for the FET and the leakage tests consists of diode CR1 and filter capacitor C4. The necessary AC voltage is taken from the 22 volt tap on the primary of the filament transformer T1. Zener diode CR2 and resistor R13 regulate the supply voltage of 8 volts so that the voltage remains constant regardless of the line voltage applied to the unit.

TROUBLE CHART

SYMPTOM	PROBABLE CAUSE	CORRECTIVE MEASURE
No meter indication on any position of Function switch.	CR1, CR2, TR1 CR3	Check diodes and power supply voltage. Check FET with FET tester and check meter for open with ohm meter.
Grid leakage measures OK, but no emission readings.	S3, T1 Grid leakage	Check resistors on C load switch with ohm meter. Check transformer for opens and Grid leakage switch position for open contacts.
Short indicator glows on one anode when checking for shorts.	Shorted or leaky	Check C3 for shorted or leaky condition and replace.
Bad tubes indicate very good or full scale	open load resistor R3 to R9 or open contacts on emission position	Check R3 to R7 for opens with ohm meter. Check contacts on Function switch.
Shorts light will not glow, even with a direct short	Open C3, open contacts on function switch	Check C3 for open and replace. Check contacts on switch.
Emission OK, but Grid leakage readings not right or absent.	Open contacts on function switch. Leakage CAL off.	Check contacts on switch. Check and reset Leakage CAL pot.

SERVICE AND WARRANTY

You have just purchased one of the finest tube testors on the market today. The Sencore Mighty Mite has been inspected and tested twice at the factory and has passed a rugged use test by our Quality Assurance Department, to insure the best quality instrument for you. If something should happen, the Mighty Mite is covered by a standard 90 day warranty as explained on the warrenty policy enclosed with your instrument.

Sencore has six regional offices to serve you. Instruments to be serviced should be returned to the nearest regional office, by UPS if possible. Parcel post should be used only as a last resort. Instruments should be packed with the original packing materials or equivelant, and double boxed to insure safe arrival at the regional office. The blue and white display carton IS NOT an acceptable shipping container. When returning an instrument for service, be sure to state the nature of the problem to insure faster service.

If you wish to repair your own Mighty Mite, we have included a schematic, trouble chart, and parts list. Any of these parts may be ordered from the regional office nearest you.

We reserve the right to examine defective parts before an in warranty replacement is issued.

SENCORE REGIONAL OFFICE

Sencore, Inc.
3200 Sencore Drive
Sioux Falls, South Dakota 57107
(605) 339-0100

MIGHTY MITE PARTS LIST

SCHEMATIC	PART	DESCRIPTION	PRICE
R2, 3	14B49-9	150 ohm 5 watt, 10%	.25
R20	15C1-12	200 ohm, 30% control	1.00
R21	15C7-14	5K vert Mt. PC control	.75
R22	15C7-8	1.2 meg vert mt PC control	.75
C1	24G81	.0062 mfd, 5% 500V poly	.25
C2	24G143	.0056 mfd, 125V poly	.25
TR1	19C11-1	FET, 2N5457	1.75
CR1	16S10	Diode, .5A, 400 PIV	.50
CR2	50C4-2	Zener diode, 8.2 volts	1.50
CR3	50C7-1	Diode, 1N816	.50
CR4	50C4-4	Zener diode, 2.2 volts	1.00
S1	25G6	1P2P slide spring return	.50
S2	25A154	2P12P rotary	4.50
S3	25A157	2P9P rotary	2.75
S4	25A156	1P3P, no detent reset	.75
S5 to S14	25A155	1P2P, 1/2 toggle slide	.50
S15	25A158	2P11P rotary	3.25
S16	25A153	5P4P rotary	3.50
M1	23B34	Meter, O-1 mA	18.25
T1	28B46	Transformer, fil and pwr	15.50
	36G2	Grid Cap lead	.75

Prices in effect at date of printing and are subject to change without notice.

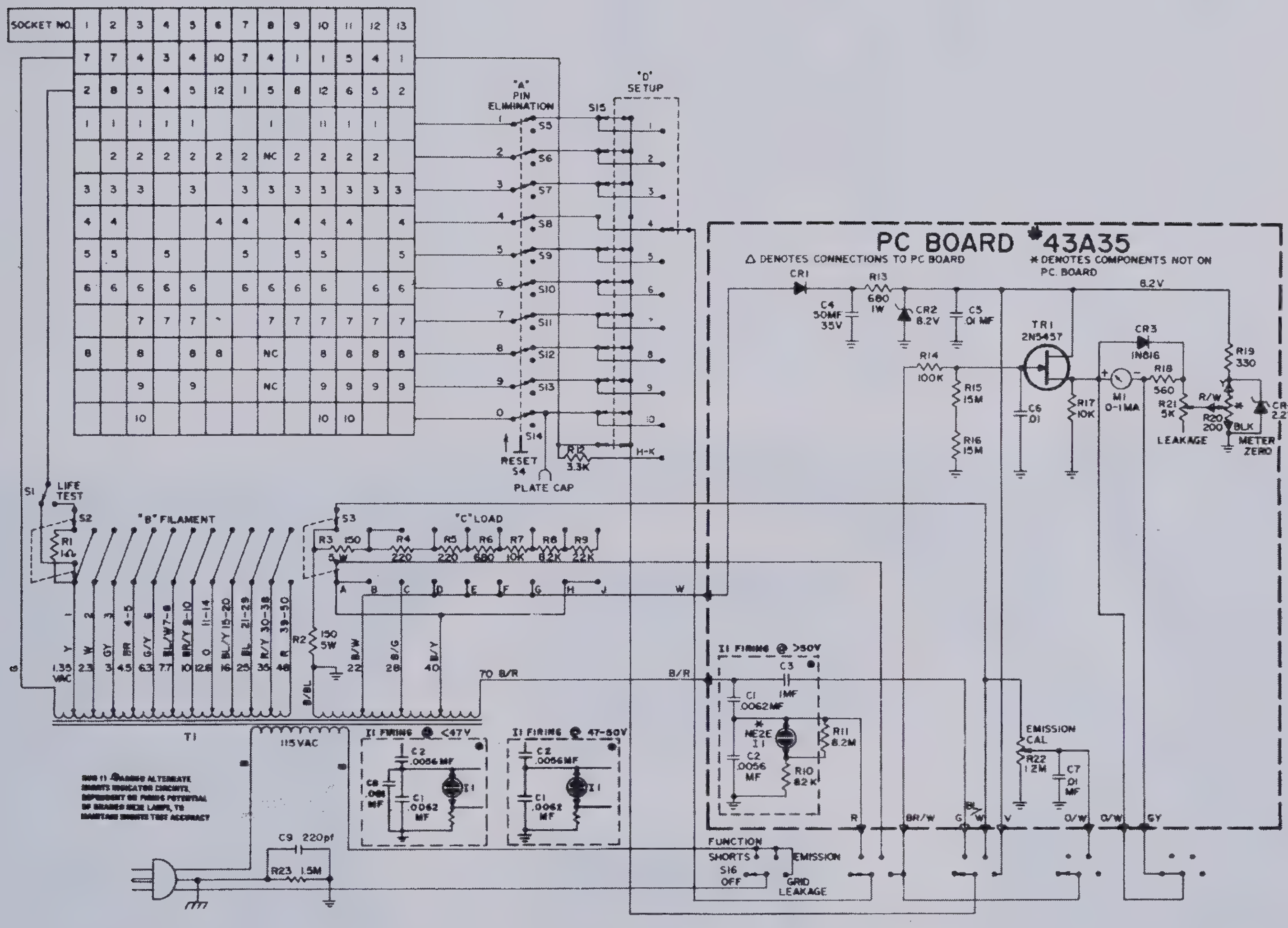
When ordering parts, please specify model number, part number and description. Service and parts invoices are C.O.D. Please include remittance (check or money order) with your order to save C.O.D. charges. Minimum billing $3.00.

Form 1162

Printed in U. S. A.

SCHEMATIC AND PARTS LIST FOR THE SENCORE TC162 MIGHTY MITE VII

THE IDEA PEOPLE
SENCORE
NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT
3200 SENCORE DRIVE • SIOUX FALLS, SOUTH DAKOTA 57107


"A" PIN ELIMINATION
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
RESET S4
PLATE CAP
S15
"D" SETUP
H-K
R12 3.3K
PC BOARD *43A35
△ DENOTES CONNECTIONS TO PC BOARD
* DENOTES COMPONENTS NOT ON PC. BOARD
CR1
R13 680 1W
C4 50MF 35V
CR2 8.2V
C5 .01 MF
8.2V
TR1 2N5457
CR3 1N816
R14 100K
R15 15M
R16 15M
C6 .01
R17 10K
M1 0-1MA
R18 560
R19 330
R21 5K
LEAKAGE
R/W
R20 200
BLK
METER ZERO
CR4 2.2V
S1 LIFE TEST
S2
R1 1Ω
"B" FILAMENT
1 2 3 4-5 6 BL/W7-8 BR/Y 8-10 11-14 BL/Y 15-20 21-29 R/Y 30-38 39-50
Y W GY BR G/Y O BL R
1.35 VAC 2.3 3 4.5 6.3 7.7 10 12.6 16 25 35 48
S3
"C" LOAD
R3 150 5W
R4 220
R5 220
R6 680
R7 10K
R8 82K
R9 22K
A B C D E F G H J
W
R2 150 5W
B/BL
B/W 22
B/G 28
B/Y 40
70 B/R
B/R
T1
115 VAC
I1 FIRING @ <47V
C2 .0056 MF
C8 .001 MF
C1 .0062 MF
I1
I1 FIRING @ 47-50V
C2 .0056MF
C1 .0062 MF
I1
I1 FIRING @ >50V
C3 1MF
C1 .0062MF
* NE2E I1
C2 .0056 MF
R11 8.2M
R10 82K
EMISSION CAL
R22 1.2M
C7 .01 MF
R
BR/W
G
BL W
V
O/W
O/W
GY
FUNCTION
SHORTS
EMISSION
S16 OFF
GRID LEAKAGE
C9 220pf
R23 1.5M
NOTE 1) ● DENOTES ALTERNATE SHORTS INDICATOR CIRCUITS, DEPENDENT ON FIRING POTENTIAL OF GRADED NE2E LAMPS, TO MAINTAIN SHORTS TEST ACCURACY

SOCKET NO.	1	2	3	4	5	6	7	8	9	10	11	12	13
	7	7	4	3	4	10	7	4	1	1	5	4	1
	2	8	5	4	5	12	1	5	8	12	6	5	2
	1	1	1	1	1			1		11	1	1	
		2	2	2	2	2	2	NC	2	2	2	2	
	3	3	3		3		3	3	3	3	3	3	3
	4	4				4	4		4	4	4		4
	5	5		5			5		5	5			5
	6	6	6	6	6		6	6	6	6		6	6
			7	7	7	[illegible]		7	7	7	7	7	7
	8		8		8	8		NC		8	8	8	8
			9		9			NC		9	9	9	9
			10							10	10		

LAST R- R23
LAST C- C9
LAST CR-CR4

TC162 MIGHTY MITE VII

ISSUE: 3-14-74

SERVICE AND WARRANTY

You have just purchased one of the finest Field Effect Meters on the market today. The FE14 and FE16 Field Effect Meters have been inspected and tested twice at the factory to insure the best quality instrument to you. If something should happen, the FE14 and FEp6 are covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument. You should never apply voltage to any ohms range of any VTVM, VOM, or Field Effect Meter. The RX1, RX10, and RX100 ohms ranges of the FE14 and FE16 cannot be protected from the application of voltages and can be damaged. Because this is misusing the ohms ranges of the instrument, the RX1, RX10, and RX100 ohms resistors are not warranteed if damaged from the application of voltage. You will be charged for both parts and labor if damage to the instrument is caused by applying voltage to the resistance ranges.

For the best service on out of warranty work, send the Field Effect Meter directly to the factory service department. Be sure to state the nature of your problem to insure faster service.

If you wish to repair your own Field Effect Meter, we have included a schematic, parts list, and trouble chart. Any of these parts may be ordered directly from the factory service department.

We reserve the right to examine defective components before an in warranty replacement part is issued.

SENCORE, INC.
3200 SENCORE DRIVE, SIOUX FALLS, S. DAKOTA 57107

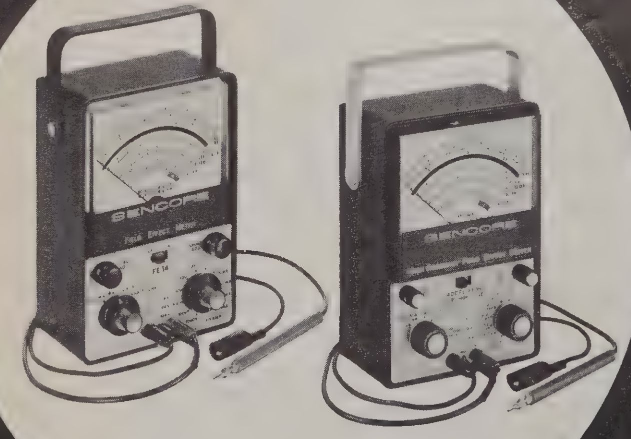
FORM NO. 431

PRINTED IN U.S.A.

FE14 AND FE16

FIELD EFFECT METER

SENCORE



SENCORE SERVICE MANUAL

3200 SENCORE DRIVE, SIOUX FALLS, S DAKOTA 57107

INSTRUCTION MANUAL FOR THE SENCORE FE14 & FE16
FIELD EFFECT METERS

The Sencore FE14 and FE16 Field Effect Meters are a revolutionary new concept in test meters. They take all the advantages of a VTVM and combine them with the advantages of a VOM to make an extremely versatile meter. High input impedance on all AC & DC voltage ranges, peak to peak AC measurements, & DC zero center scales combined with zero warm up time, DC current ranges, and VOM portability makes the Field Effect Meter a truly great instrument. Anyone in the electrical or electronic fields - service technicians, engineers, field engineers, hams, experimenters etc. - will find that the Field Effect Meter is the complete answer to his measuring needs.

No other meter in the FE14 or FE16 class has all of these features in one instrument:

* High input impedance on both AC and DC voltage ranges (10 megohms and 15 megohm)

* True peak to peak AC ranges.

* Zero center ranges for solid state servicing.

* DC current ranges for general testing.

* Mirrored scale meter for greater accuracy in readings.

* Meter protected from overloads.

* Circuit protected from accidental application of wrong voltages.

* All steel construction for greater durability.

* Battery operated for complete portability.

FE14 SPECIFICATIONS

DC VOLTS
Ranges: 0 to 1, 3, 10, 30, 100, 300 and 1000 FULL SCALE
-.5 to .5, - 1.5 to 1.5, -5 to 5, -15 to 15, -50 to 50, -150 to 150 and -500 to 500 ZERO CENTER SCALE RANGES
Input Resistance: 15 megohms shunted by 14 PF.
Accuracy: ± 2 1/2%
AC Rejection: 30 to 300 times (30 to 50db).

AC VOLTS
Ranges: (Rms)
0 to 1, 3, 10, 30, 100, 300 and 1000 FULL SCALE
Ranges: (Peak to Peak)
0-2.8, 8.4, 28, 84, 280, 840 and 2800 Full Scale, frequency compensated
Input Resistance: 10 megohms shunted by 29 PF.
Frequency Response: Flat: 25HZ to 1MHZ
3db points: 10Hz to 10MHz
Accuracy: ± 4 1/2%

FE16 PARTS LIST

REFERENCE NO.	PART NO.	DESCRIPTION	PRICE
CR1, CR2, CR6	19G28A	Diode, Germanium	$ .50
CR3, CR4	16G5	Diode rectifier .5A @400PIV	1.50
CR5	19G13	Diode, 1N34A	.50
CR7	50G2	Diode, Silicon	.65
M1	23C30	Meter 4 1/2", 100 microamp 1900 ohm coil	24.50
R1	14G271	5 meg 1/2W 1%	.75
R2	14G315	10K 1/2W 1/2%	1.25
R3	14G309	23.3K 1/2W 1/2%	1.25
R4	14G310	66.7K 1/2W 1/2%	1.25
R5	14G311	233K 1/2W 1/2%	1.25
R6	14G312	667K 1/2W 1/2%	1.25
R7	14G313	2.33 meg 1/2W 1/2%	1.25
R8	14G314	6.67 meg 1/2W 1/2%	1.25
R9	14G264	9.1 ohm 1/2W 1%	.75
R10	14G265	100 ohm 1/2W 1%	.75
R11	14G101	1K 1/2W 1%	.75
R15	15G61	5K control PC Vert Mount	.75
R16	14G275	220 ohm 1/2W 1%	.75
R17	14G274	20 ohm 1/2W 1%	.75
R18	14G273	2 ohm 1/2W 1%	.75
R19	14G143	8 1/4" Advance wire (.295 ohms ft)	.75
R23	15A75	15K control Tab mount 1" shaft	1.50
R26	15G66	1/2 meg control PC Vert Mount	1.95
R29	15A53	10K control PC Vert Mount	1.95
R31	15A68	50K control tab mount 1" shaft	1.95
TR1, TR2	19G27	Transistor SS3672 (FET)	1.50
C2	24G173	.015 mf 10% mylar	.25
C3	24G179	5600PF 5% N150	.25
C4	24G174	2100PF 5% N150	.25
C5, C9	24G141	560PF 5% N150	.25
C6	24G178	200PF 5% N150	.25
C18	24G120	10MF, 15 volts	.35
S1	25A105	Range Switch 7P12P rotary	9.95
S2	25A115	Function Switch 8P4P rotary	$ 8.95
S3	25G4	Slide Switch SPDT	.50
	10C239	Case, vinyl clad steel	4.50
	10A222A	Battery plate (door)	.50
	33G143	Battery clip (1.5v "C" cell)	.50
	33G226	Battery clamp (9 volt)	.50
	35G16	Battery plug 8" leads	.75
	8B12	Panel sub, vinyl clad steel	3.00
	8A13	Panel, aluminum	3.00
	39G24	Test Probe with shielded lead	2.50

(PRICES SUBJECT TO CHANGE WITHOUT NOTICE)

MEASURING EXTREMELY SMALL CURRENTS WITH THE FE14 AND FE16

Very small currents nanoamps (.001 ua) may be measured using the Field Effect Meter in conjunction with a 3 volt battery.

Leakage currents of transistors and diodes and leakage currents through paper or electrolytic capacitors can be measured.

To make nanoamps measurements set the Function Switch to +DCV/ma and Range Switch to 3 volts. Connect the 3 volt battery across the input terminals; meter should read full scale or slightly higher. Connect transistor diode or capacitor between one battery terminal and the Field Effect Meter input. Observe polarity when connecting to device to obtain an accurate indication. Read current on ma scale and multiply reading by 200. Current measured will be in nanoamps. For example;

a germanium diode leakage indication is .98 ma. .98 x 200 = 196 nanoamps
a silicon diode leakage indication is .1 ma. .1 x 200 = 20 nanoamps

OVERLOAD PROTECTION ON THE FE14 AND FE16

The circuits and meter of the Field Effect Meters are protected from accidental overloads and application of excessive voltages. A silicon diode protects the transistors and circuit from damage. The meter is protected by two diodes and a resistor. The diodes shunt excessive current around the meter. If the current is excessivly high or is applied for too long a period of time, the fuse resistor R24 will burn out protecting the meter and diodes. When this resistor is open, the current and ohms function of the Field Effect Meters will be inoperative, but the meter can still be used to measure voltage. R24 is a standard 100 ohm, 1/2 watt, 10% resistor, located on the Range switch, and is readily accessable when the meter is removed from the case.

DISASSEMBLY INSTRUCTIONS

The Field Effect Meter does not have to be taken apart to replace the batteries. The door on the back of the Field Effect Meter gives access to the batteries and battery clips for ease of replacement. If the Field Effect Meter must be serviced or calibrated, the battery door must first be removed. Then the two screws holding the front panel to the case are removed. This allows the front panel to be lifted out for service. To separate the front panel from the case, the battery door with the batteries must be passed through the hole in the back of the case.

BATTERY REPLACEMENT: To replace the batteries in the Field Effect Meter, remove the screw holding the battery plate in the back of the instrument. The battery plate will slip out exposing the batteries in the clips on the plate.

The 9 volt battery can be replaced by any standard 9 volt transistor battery. An Eveready type #222 or equivelent is recommended as it will give longer battery life. The 1.5 volt "C" cell can be replaced by any standard "C" cell. One of the many long life types will provide longer life in use. To conserve on battery life, the Field Effect Meter should be turned off when not in use or when measuring current. The 9 volt battery is used only when the Field Effect Meter is measuring AC and DC volts and resistance.

CALIBRATING THE FE14 AND FE16

The Field Effect Meter may be recalibrated easily and quickly if it becomes necessary by simply removing the battery plate. This will expose the controls on the printed board. Figure three shows the location of these controls. The 9 volt battery should be replaced with a fresh one if the Field Effect Meter is to be completely recalibrated. The DC BAL and the meter mechanical zero must be checked and readjusted if necessary before recalibrating the unit.

1. Set the front panel ZERO ADJ to the mechanical center of its rotation, the Range switch to the 1000 volt position, and turn the Field Effect Meter on.

2. With the Function switch in the plus DCV/MA position, adjust the DC BAL for a zero meter indication. Switch to minus DCV/MA. If the meter pointer moves, recheck and reset the meter mechanical zero with the Field Effect Meter turned off. Recheck the DC BAL for a zero meter indication.

3. Set the Range switch to the 1 volt position and the Function switch to ACV/OHMS. Apply a known 1 volt AC RMS voltage and adjust the AC CAL for full scale meter deflection. Remove your hand from the AC CAL pot to be sure you are not picking up any stray AC and adding it to the calibration of the Field Effect Meter. If an accurate source of AC is not available, the AC line may be used. In this case, set the Range switch to the 300 volt position and adjust the AC CAL control to read the line voltage. This will normally be 115 to 117 volts.

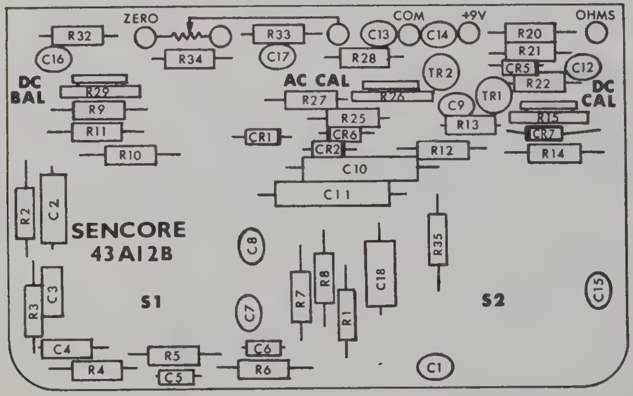


FIGURE 3

4. DC calibration is achived by setting the Function switch to plus DCV/MA and the Range switch to the 1 volt position. Apply a known 1 volt DC source and adjust the DC CAL for a full scale deflection on the meter. A 1.5 volt battery may also be used to calibrate the Field Effect Meter. Set the Range switch to the 3 volt position and adjust the meter to indicate 1.55 volts which is the normal voltage from a new 1.5 volt battery. A more accurate calibration may be achived with a mercury battery as its voltage is more constant and has closer tolerance.

CIRCUIT DESCRIPTION:

The Sencore FE14 and FE16 Field Effect Meters uses a balanced differential amplifier with field effect transistors (FET) to provide the utmost in test meters - the flexability and portability of a VOM with all the advantages of a VTVM, high input impedance, peak to peak AC etc.

Field effect transistors make this possible, because even though they are "solid state" they perform like a vacuum tube. The gate (grid) controls the current flow between the source (cathode) and drain (plate) by the effect of the electrostatic field between the gate and the source (bias). There isn't any gate current flow therefore the input impedance is extremely high. Since the FET does not have a cathode to "wear out" the Field Effect Meter is more stable and less subject to change than the conventional VTVM.

TR1 and TR2 (see schematic fig. 4) form the differential amplifier used for DC volts and Ohms measurements. With no voltage applied to the input of TR1, the ZERO ADJ control (R31) is set so that the voltages developed across source resistors R14 and R22 are equal, such that no current will flow thru the meter. The DC BAL control (R29) is an internal adjustment that performs the same as the ZERO ADJ control. It is used to compensate for component tolerances. When a DC voltage is applied to the input of TR1 the balance between TR1 and TR2 is upset and the meter will indicate in proportion to the voltage applied. Seven DC and AC ranges are provided with the input divider R1 thru R8. Capacitors C2 thru C8 compensate the divider for AC voltages. The DC CAL control (R15) is an internal adjustment used to calibrate the meter when a known DC voltage is applied to the input. When a very high voltage is applied to the gate of TR1 (Range switch set incorrectly) diode CR7 will conduct and keep the voltage applied to TR1 to a safe level to prevent destruction of the transistor.

Ohms measurements are made by forming a voltage divider with the unknown resistor and a known resistor - R9 for RX1 range, R10 for RX10 range etc. - and reading the voltage that is developed across the known resistor. Initially with the unknown resistor zero (leads shorted together) the OHMS ADJ control (R23) is set so that the meter reads at full scale with full potential from B1 applied to TR1. As external resistance is placed between the leads the meter will indicate proportionately lower. The meter is calibrated in ohms on the top scale.

For AC voltage measurements the AC voltage is applied to TR1 thru divider R2-R8 as with DC volts. The output of TR1 is fed to a peak to peak detector consisting of C10, C11, CR1 and CR2. The DC output is fed to TR2 thru divider R25, R26, R27 and CR6. The meter is in the source circuit of TR2. The DC voltage developed in the source of TR2, and consequently the meter indication is proportional to the peak to peak AC applied to TR1. Diodes CR5 and CR6 compensate for changes in temperature so that meter indications remain accurate over a wide temperature range.

DC current measurements are made using the meter and shunt resistors R16 thru R19. The transistors and associated circuitry are not used. On the 100 microamp range the meter is connected directly into the circuit.

Diodes CR3 and CR4 protect the meter movement from excessive overloads up to several amps. The diodes are protected with resistor R24 which will burn out when the maximum current rating of the diodes is exceeded. R24 is a standard 100 ohm 1/2 watt resistor.

To use the 10 amp adaptor, plug it into the jacks on the Field Effect Meter. Set the range switch to the 100 microamp position and the Function switch to plus DCV/MA. The Field Effect Meter does not need to be turned on for current measurements. Multiply the readings on the 0 - 1 DC volts scale by 10 to get the current in amps. If the meter reads backwards, reverse the polarity by switching the minus DCV/MA position.

Double 3/4" Banana plug Mfg.	Mfg. part number
E. F. Johnson	Type 108
General Radio	274-MB
National	FWT
Pomona	MDP-AMDP-ST

MEASURING AC CURRENT WITH THE FE14 AND FE16

The Field Effect Meter can be used to measure AC current with the circuit shown below. The resistor or resistors are placed in series with the AC source going to the device under test. The AC voltage drop across the resistor is measured and can be converted directly into AC amps. This adaptor may be built in a box with a switch to facilitate the switching. The resistors used are all one ohm of at least one watt. The Ohmite 995 series of 1 1/2 watt wirewound are ideal for this. A standard one watt carbon resistor will also work. If the unit is to be used for an extended period of time and is enclosed in a box, it is a good idea to use a two watt carbon in place of the one watt carbon resistor.

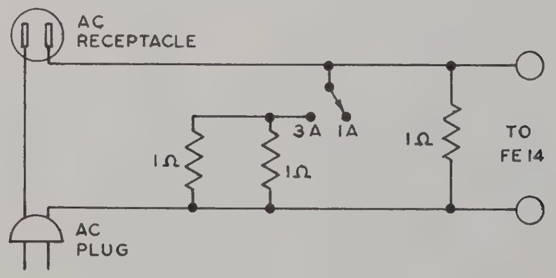


FIGURE 2

When measuring from zero to one amp, the one ohm resistor is used and the Function switch is set on ACV/OHMS and the Range switch to the one volt position. To measure three amps of AC current, three resistors are placed in parallel. The Range switch remains on the one volt range, but the three volt scale is read directly in amps. A 10 amp range can also be made by paralleling 10 one ohm resistors and using the one volt scale, multiply your readings by 10.

The 39A19 High Voltage Probe is an optional assessory, used to extend the DC range of the Field Effect Meter to 30,000 volts. It contains a 1,485 megohm 2% resistor to give a 100X multiplier for any range of the Field Effect Meter. The special ranges of 3KV for boost voltages, 10KV for focus and 30KV for high voltage are marked right on the front panel. Do not measure voltages higher than 30KV with the 39A19 high voltage probe, as the maximum rating of the resistor is 30KV.

To use the High Voltage Probe, simply plug the test lead into the red jack of the Field Effect Meter and connect the black lead from the black jack to ground. Set the function switch to + DCV/MA (-DCV/MA if you are measuring a negative voltage) and the range switch to the 3KV, 10KV, or 30KV position depending upon the voltage to be measured.

To read the actual voltage, multiply the readings on the 3 volt scale by 1000 for the 3KV position, the 1 volt scale by 10,000 for the 10KV position, and the 3 volt scale by 10,000 for the 30KV position.

The High Voltage Probe can also be used to measure voltages of 100, 300, and 1000 volts DC with an input impedance of 1,500 megohms. To obtain this high input impedance, set the range switch to the 1, 3, or 10 volt range and measure the voltage using the 39A19 High Voltage Probe.

CHECKING THE BATTERIES OF THE FE14 AND FE16

The 9 volt transistor battery used in the Field Effect Meter can readily be checked using the BATT. CHK. position of the Function switch. The range switch may be in any position and will not effect the reading of the battery condition. If the meter reads in the green area or BATT GOOD section of the meter (lower right hand corner) the battery is good and the readings taken with the Field Effect Meter will be accurate. If the meter reads below the green area, the battery should be replaced. The ohms battery can also be checked easily by using the same scale on the Field Effect Meter. Set the switch to ACV-OHMS and the Range switch to Rx10. Adjust the meter for zero indication on the left edge of the scale with the ZERO ADJ control. Short the leads together and set the OHMS ADJ for full scale meter indication. Without unshorting the leads, switch the RANGE switch to RX1. If the meter reads in the green area or BATT GOOD (lower right hand corner) the ohms battery is good. If it reads below this, the ohms battery should be replaced.

MEASURING HIGH DC CURRENT

Up to 10 amps of DC current can be measured with the Field Effect Meter adaptor below. Use a double 3/4 inch banana plug and two feet of number 20 copper wire to form the shunt. The leads carrying the current to the shunt should be a number 14 or heavier with heavy clips to connect into the circuit.

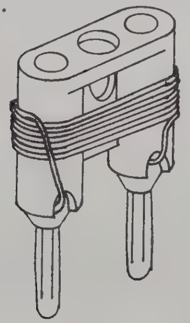
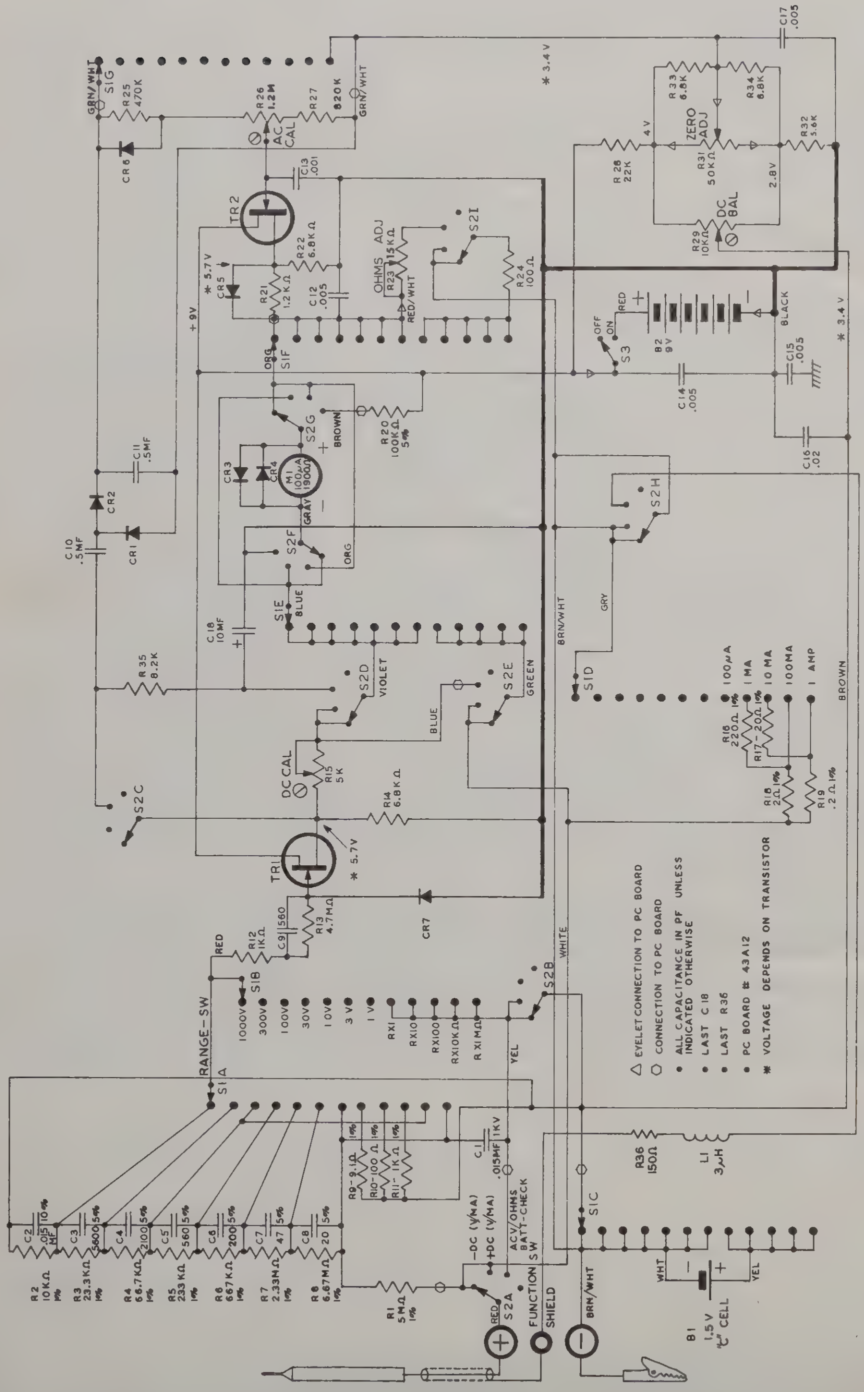


FIGURE 1

FIELD EFFECT METER TROUBLE CHART

Symptom	Probable Cause	Corrective Measure
Unit dead, meter does not read at all	Defective 9V battery (B2) Poor battery contact Broken red wire at ON OFF switch (S3) or at PC board Broken black wire from battery to PC board Defective Meter Shorted Diode CR3 or CR4	Replace battery Check battery contacts Check wiring to switch and to PC board Check black wire Replace Meter Replace defective diode
VOLTS measurements ok; but no indication on OHMS and MILLIAMPS functions	Burnt out fuse resistor R24	Replace R24, 100 ohms 1/2 w 10%
Cannot zero meter	Function and range switches in current positions. Poor contact at or/open resistor R32 Broken wire to zero adj control Transistors burnt out	Reset switches to correct positions Resolder contact and change resistor if necessary Check wire to zero adj control. Replace transistors and recalibrate unit.
RX1 Function in Ohms measurement does not work.	Burnt out resistor R9	Replace resistor
RX10 Function in Ohms measurement does not work.	Burnt out resistor R10	Replace resistor
1 ma function only in current measurements does not work.	Burnt out resistor R16	Replace resistor
10 ma function only in current measurements does not work.	Burnt out resistor R17	Replace resistor
Cannot adjust Ohm zero to o	Blue wire to ohms zero broken Poor contact at battery B1 Broken wire to battery contact Weak battery B1	Check for broken wire Check for poor contacts Check wiring Replace with 1.5 volt "C" cell.


△ EYELET CONNECTION TO PC BOARD
○ CONNECTION TO PC BOARD
• ALL CAPACITANCE IN PF UNLESS INDICATED OTHERWISE
• LAST C 18
• LAST R36
• PC BOARD # 43A12
* VOLTAGE DEPENDS ON TRANSISTOR
RANGE-SW
S1A
S1B
1000V
300V
100V
30V
10V
3V
1V
RX1
RX10
RX100
RX10KΩ
RX1MΩ
TR1
TR2
DC CAL
AC CAL
ZERO ADJ
DC BAL
OHMS ADJ
M1 100μA 1900Ω
B1 1.5V "C" CELL
B2 9V
S3 OFF ON
FUNCTION SW
SHIELD
ACV/OHMS BATT-CHECK
-DC (V/MA)
+DC (V/MA)
100μA
1 MA
10 MA
100MA
1 AMP
L1 3μH
R36 150Ω
+9V
* 3.4V
* 5.7V
4V
2.8V

FE 14 SCHEMATIC

ISSUE DATE:

range switch is on the 10 volt range and the meter reads .42 volts, the actual voltage is .42 times 10 or 4.2 volts DC.

READING AC VOLTS: To read AC volts, the Function switch is set to the ACV/OHMS position and the Range switch to the desired range. For RMS voltages the two black scales marked AC (RMS) are used. For peak to peak voltages, the two red scales directly below the AC (RMS) scales are used. The readings are multiplied in the same way as with the DC scales, to obtain the actual voltage present. On the zero to 1.0 AC (RMS) scale, each mark is .02 volts and on the zero to 3.0 volts scale, each mark is .1 volts. On the zero to 2.8 volts AC (P-P) scale, each mark is .1 volts and on the zero to 8.4 volts scale, each mark is .2 volts.

READING DC VOLTS ZERO CENTER SCALE: The zero center scales are used to read plus or minus voltages without the necessity of changing polarity with the leads or Function switch. To use the zero center scales, set the Function switch to plus DCV/MA position and adjust the ZERO ADJ until the meter reads at the zero mark in the center of the scale. This gives ranges of plus or minus .5 volts (top scale) or plus or minus 1.5 volts (bottom scale) times 10, 100, or 1000 depending upon the setting of the range switch. If the range switch is in the 300 volt position, the zero to 1.5 volts scale is used and becomes zero to 150 volts plus or minus. If the meter swings up scale or to the right, it is a positive voltage. If the meter swings down scale or to the left, it is a negetive voltage. This unique feature allows you to determine the polarity as well as the amplitude of a DC voltage and is very handy in solid state servicing.

READING OHMS: To read resistance, set the Function switch to ACV/OHMS and the Range switch to the desired range of resistance to be read. After checking to see that the meter is "zeroed" at the left edge of the scale, short the leads together and adjust the OHMS ADJ control for full scale deflection of the meter. Unshort the leads and be sure that the meter returns to the extreme left of the scale. Place the unknown resistance between the two leads and read the resistance on the OHMS scale (top red scale on meter). Multiply the reading on the meter by the range used. For example, if the meter read 15 and the range switch was set on RX100, the actual resistance would be 15 times 100 or 1500 ohms. CAUTION: When making ohms measurements, be sure that the power to the circuit is turned off. The application of excessive voltages to the RX1, RX10, and RX100 ohms ranges can damage the internal standard resistor of the Field Effect Meter.

MEASURING DC CURRENT: To measure DC current, the Function switch is set to either the plus or minus DCV/MA position and the Range switch to the desired range of current. The power to the Field Effect Meter does not have to be turned on and may be left off to conserve on battery life if you so desire. Connect the leads in series and read the resultant current on the meter. The 0 to 1.0 DC VOLTS (MA) scale is used on all current measurements. If the meter reads backwards, indicating that the leads are reversed, simply change the polarity with the Function switch to the opposite polarity and the meter will read up scale.

MEASURING HIGH VOLTAGE WITH THE FE14 AND FE16

CAUTION: High voltage is dangerous and caution should be observed when measuring high voltages. Be sure that the ground lead from the Field Effect Meter is connected to the ground on the unit. If the ground lead is not connected, you are merely extending the high voltage closer to you. Stand away from the unit you are measuring and keep one hand in your pocket as a safety measure. High voltage in color TV is especially dangerous because it can go as high as 30,000 volts and is regulated. If you should come across it, it will not load down.

OFF-ON switch: The OFF-ON switch controls the power to the circuit in the Field Effect Meter. In the OFF position, the battery is disconnected from the circuit and the meter is off. In the ON position, the battery voltage is applied to the circuit and the meter is ready to go. A red flag appears in the switch opening to indicate when the Field Effect Meter is on. When measuring current, the OFF-ON switch may be left in the OFF position as no battery power is needed.

ZERO ADJ: The ZERO ADJ is used to position the pointer of the meter over the zero on the extreme left of the meter scale or to position the pointer on the center zero when using the zero center ranges of the Field Effect Meter.

OHMS ADJ: The OHMS ADJ is the same as that found on most meters. Prior to measuring resistance, the test leads are shorted together and the OHMS ADJ is rotated for a full scale deflection (zero ohms) as read on the ohms scale of the meter.

FUNCTION SWITCH: The FUNCTION switch selects the type of measurement to be preformed. Minus or Plus DC Volts or MA, AC volts or OHMS and the BATT. CHK.

RANGE SWITCH: The RANGE switch selects the desired range of current, voltage, or resistance to be measured.

SHIELDED LEAD ON THE FE14 & FE16

The Sencore Field Effect Meters are equipped with a shielded lead on the positive input lead so that accurate AC measurements can be made in the presence of strong electrostatic and magnetic fields. The shield, which is also effective on high ohms ranges, is only connected when using the AC Volts/Ohms functions and is disconnected when making DC measurements to prevent capacitive loading of the circuit being measured.

Test lead connections to the FE14 or FE16 are made through the red and black banana jacks. The shield connects through a small pin jack (plainly marked) so that it cannot be mistakenly used as one of the test lead connections.

OPERATING THE FE14 and FE16

The Sencore Field Effect Meters are simple and easy to operate. Set the Function switch to the desired test to be preformed, the RANGE switch to the desired range, connect the leads and read the results on the meter. Here is a brief description of how each test is performed.

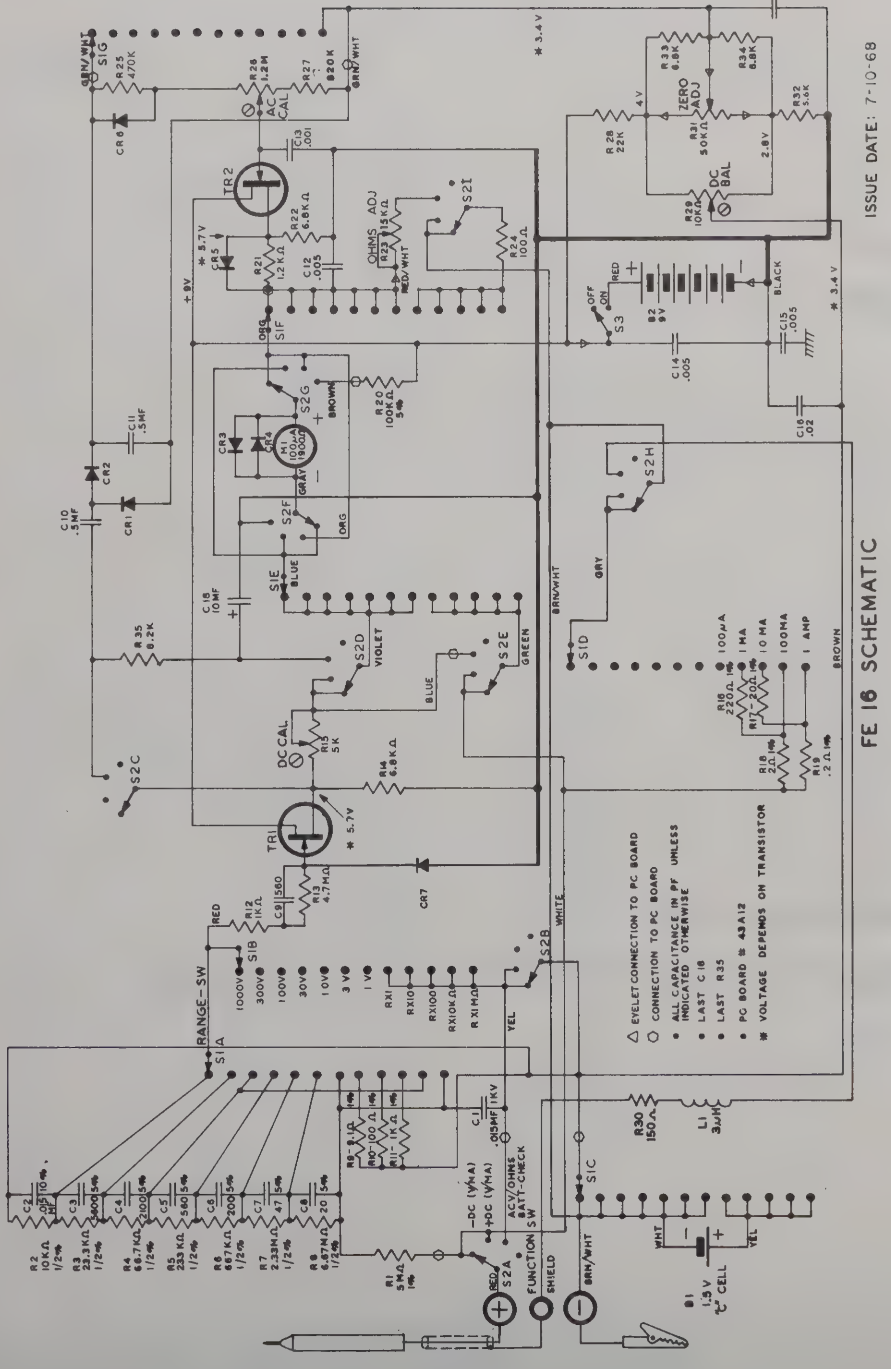
READING DC VOLTS: To read DC volts, the Function switch is set to either plus or minus DCV/MA. The Range switch is set to the desired range of voltage from one volt to 1000 volts full scale. If the voltage to be measured is unknown, start with the highest range and work down until the voltage can be measured. Connect the leads to the circuit and read the results on the meter. When measuring voltage in RF-IF circuits, a 100K isolation resistor at the end of the red test lead will reduce capacitive effects without effecting accuracy of readings.

The DC voltage is read on the two black scales just above the mirror on the meter. The top DC scale is from zero to 1.0 volts and each mark is equal to .02 volts. The bottom scale is zero to 3.0 volts and each mark is equal to .1 volts. The zero to 1.0 scale is used for the 1, 10, 100, and 1000 volt ranges and the zero to 3.0 scale is used for the 3, 30, and 300 volt ranges. In use the meter indication is multiplied by 10, 100, or 1000 depending upon the range. For example, if the

FE14 PARTS LIST

REFERENCE NO.	PART NO.	DESCRIPTION	PRICE
CR1, CR2, CR6	19G28A	Diode, Germanium	$ .50
CR3, CR4	16G5	Diode rectifier .5A @400PIV	1.50
CR5	19G13	Diode, 1N34A	.50
CR7	50G2	Diode Silicon	.65
M1	23C25B	Meter 4 1/2", 100 microamp 1900 ohm coil	24.50
R1	14G271	5 meg 1/2W 1%	.75
R2	14G103	10K 1/2W 1%	.75
R3	14G266	23.3K 1/2W 1%	.75
R4	14G267	66.7K 1/2W 1%	.75
R5	14G268	233K 1/2W 1%	.75
R6	14G269	667K 1/2W 1%	.75
R7	14G270	2.33 meg 1/2W 1%	.75
R8	14G272	6.67 meg 1/2W 1%	.75
R9	14G264	9.1 ohm 1/2W 1%	.75
R10	14G265	100 ohm 1/2W 1%	.75
R11	14G101	1K 1/2W 1%	.75
R15	15G61	5K control PC Vert Mount	1.50
R16	14G275	220 ohm 1/2W 1%	.75
R17	14G274	20 ohm 1/2W 1%	.75
R18	14G273	2 ohm 1/2W 1%	.75
R19	14G143	8 1/4" Advance wire (.295 ohms ft)	.75
R23	15A75	15K control Tab mount 1" shaft	1.50
R26	15G66	1.2 meg control PC Vert Mount	1.95
R29	15A53	10K control PC Vert Mount	1.95
R31	15A68	50K control tab mount 1" shaft	1.95
TR1, TR2	19G27	Transistor SS3672 (FET)	1.50
C2	24G173	.015 mf 10% mylar	.25
C3	24G179	5600PF 5% N150	.25
C4	24G174	2100PF 5% N150	.25
C5, C9	24G141	560PF 5% N150	.25
C6	24G178	200PF 5% N150	.25
C18	24G120	10MF, 15 VOLTS	.35
S1	25A105	Range Switch 7P12P rotary	$ 9.95
S2	25A104	Function Switch 8P4P rotary	8.95
S3	25G4	Slide Switch SPDT	.50
	10C215C	Case; vinyl clad steel	4.50
	10B216A	Panel, satin chrome screened	3.25
	10A222A	Battery plate (door)	.50
	33G143	Battery clip (1.5v "C" cell)	.50
	33G226	Battery clamp (9volt)	.50
	35G16	Battery plug 8" leads	.75
	39G24	Test Probe with shielded lead	2.50

(PRICES SUBJECT TO CHANGE WITHOUT NOTICE)


FE 16 SCHEMATIC
ISSUE DATE: 7-10-68
△ EYELET CONNECTION TO PC BOARD
○ CONNECTION TO PC BOARD
• ALL CAPACITANCE IN PF UNLESS INDICATED OTHERWISE
• LAST C 18
• LAST R 35
• PC BOARD # 43A12
* VOLTAGE DEPENDS ON TRANSISTOR
RANGE-SW
FUNCTION SW
SHIELD
TR1
TR2
M1 100μA 1900Ω
B1 1.5V "C" CELL
B2 9V
ZERO ADJ
DC BAL
OHMS ADJ
AC CAL
DC CAL
1000V
300V
100V
30V
10V
3V
1V
RX1
RX10
RX100
RX10KΩ
RX1MΩ
100μA
1 MA
10 MA
100MA
1 AMP
ACV/OHMS BATT-CHECK
+DC (V/MA)
-DC (V/MA)

OHMMETER
Ranges: 0 to 1000 ohms, 10K, 100K, 10 megohms and 1000 megohms
Accuracy: ± 2 degrees ARC

DC CURRENT MEASUREMENTS
Ranges: 0 - 100 microamps, 1ma, 10ma, 100ma and 1 Ampere
Accuracy: ± 3%
Internal Voltage Drop: 200 MV

FE16 SPECIFICATIONS

DC VOLTS
Ranges: 0 to 1, 3, 10, 30, 100, 300 and 1000 FULL SCALE
-.5 to .5, -1.5 to 1.5, -5 to 5, -15 to 15, -50 to 50, -150 to 150 and -500 to 500 ZERO CENTER SCALE RANGES
Input Resistance: 15 megohms shunted by 14 PF at jack or 37 PF thru cable
Accuracy: ± 1.5%
AC Rejection: 30 to 300 times (30 to 50db).

AC VOLTS
Ranges: (Rms)
0 to 1, 3, 10, 30, 100, 300 and 1000 FULL SCALE
Ranges: (Peak to Peak)
0-2.8, 8.4, 28, 84, 280, 840 and 2800 Full scale, frequency compensated
Input Resistance: 10 megohms shunted by 29 PF at jack or 118 PF thru cable
Frequency Response: Flat: 25HZ to 1MHZ
3db points: 10Hz to 10MHz
Accuracy: ± 3%

OHMMETER
Ranges: 0 to 1000 ohms, 10K, 100K, 10 megohms and 1000 megohms
Accuracy: ± 2 degrees ARC

DC CURRENT MEASUREMENTS
Ranges: 0 - 100 microamps, 1ma, 10ma, 100ma and 1 Ampere
Accuracy: ± 3% full scale
Internal Voltage Drop: 200MV

GENERAL SPECIFICATIONS ON FE14 AND FE16

Meter: 4-1/2", 100 microamp ± 2%, diode protected and isolated from input
Multiplier Resistors: 1% precision type on FE14; 1/2% on FE16
Ohms Battery: 1.5V "C" cell, Eveready Type #1035 or equivalent
Power supply battery: 9 volt, Eveready Type #222 or equivalent
Weight (less Batteries): 3-1/4 lbs.
Dimensions: 5" w x 7-3/16"h 3-1/16d
Accessories: High Voltage probe (39A19) extends range to 30KV.

CONTROLS ON THE FE14 & FE16

The Field Effect Meter is as simple to operate as a standard VOM. Panel controls include the RANGE switch, FUNCTION switch, meter ZERO ADJ, OHMS ADJ, and the off-on switch. The following is a brief description of each control and how it is used.

SM
158
SPEED ALIGNER
SWEEP AND MARKER
GENERATOR

SENCORE

SENCORE SERVICE MANUAL

3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

Safety Precautions

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. An isolation transformer should always be used on equipment having the chassis tied to one side of the AC power line.
2. When making test lead connections to high voltage points, remove the power. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.
3. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.
4. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.
5. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.
6. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with high voltages.

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INSTRUCTION MANUAL FOR THE SENCORE
SM158 SPEED ALIGNER SWEEP AND MARKER GENERATOR

DESCRIPTION

Faster and more accurate alignment equipment has been demanded by the electronic maintenance field. Sencore engineers have met this demand in the SM158 Speed Aligner. The Speed Aligner gives the required IF and chroma sweep signals and four RF channels for tuner checking with up to 44 different crystal controlled markers. These features along with the simplicity of operation makes the SM158 Speed Aligner ideal for the service industry. Compare these features and see why the SM158 is truly a unique sweep generator.

*Flat output generates text book response curves.
*Full 15MHz sweep width.
*All prefixed frequencies for faster and easier alignment.
*Up to 44 different crystal controlled markers for chroma, IF and RF channels.
*Horizontal or Vertical markers.
*Small, compact and easy to use.

SPECIFICATIONS

RF Output: Variable 10uV to over 100mV, flatness ±1.5db
Frequency Coverage: IF, and RF channels 3, 4, 10 and 13
Chroma: 45.75 MHz picture carrier with 42.17 MHz swept subcarrier
Sweep: Variable, 0.3-15MHz; linearity 1.5% sweep rate 60Hz
Markers (Post Injection System used):
TV IF crystal controlled markers:
39.75, 41.25, 41.67, 42.17, 42.67, 44.25, 45.75, 47.25 MHz
Chroma crystal controlled markers:
3.08, 3.58, 4.08 MHz
Sound IF crystal controlled marker:
4.5 MHz
TV RF Markers: Adj. sound trap, IF carrier, color carrier and sidebands, sound carrier, and adj. video trap
SIZE: 7"HX 10 3/4"LX6"D
WEIGHT: 9 Lbs.

SEMICONDUCTOR COMPLEMENT

17 Bi Polar transistors
1 Junction FET
1 Dual Gate MOSFET
3 Diodes
3 Zener Diodes
2 Varicap diodes

OPERATION

CONTROLS ON THE SM158 SPEED ALIGNER

SWEEP OUTPUT SWITCH: Selects one of the Six different frequencies used for alignment of the TV receiver.

FINE TUNING CONTROL: Allows the response curve to be shifted several megahertz either side of center for faster trap alignment.

SWEEP HEIGHT CONTROL: Controls the RF output level from the SM158 Speed Aligner.

SWEEP WIDTH CONTROL: Varies the sweep width from about .1MHz to 15 MHz.

RF OUTPUT JACK: All sweep signals from the SM158 appear at this jack.

CRYSTAL CONTROLLED MARKERS PUSH BUTTONS: Used to select one or more of the total 44 different marker frequencies used in IF, RF, and Chroma alignment.

MARKER HEIGHT: A variable control so that the desired height of marker can be placed on the screen according to the users wishes. The push-pull switch on the MARKER HEIGHT control allows the selection of either vertical or horizontal markers to be displayed on the response curve.

DETECTOR IN JACK: The signal from the TV receiver is put into the jack with the 39G23 detector probe.

SCOPE VERT. JACK: Provides the response curve and vertical markers for the vertical input to the scope.

SCOPE HORIZ. JACK: Provides a 60 Hertz horizontal sweep for scopes not having an internal line position and markers for the horizontal marker position of the MARKER HEIGHT Control. No horizontal markers will appear unless this jack is used.

OFF-ON SWITCH: Controls the AC power to the unit and glows in the on position acting as a pilot light.

PHASE ADJUST: Adjusts the phase of the horizontal signal to the scope to compensate for phase errors in the scope and is located on the rear of the Speed Aligner.

39G22A MATCHING PAD

The 39G22 matching pad that comes with the Speed Aligner is used to match into the mixer test points for IF and chroma; the 300 ohm input of the tuner for RF alignment; and is used to terminate the RF cable to eliminate standing waves and distortion of the response curve. If the matching pad is not used, serious standing waves can result causing the response curve to be tilted and the results will be questionable. If a 75 ohm input such as a distribution system or cable system is to be checked, the 75 ohm output cable can be used directly without the matching pad. When connecting the 300 ohm antenna input use the red and green leads. When connecting to the mixer test point or other low impedance point, use the black lead to ground and the red lead to the test point or ungrounded tube shield.

39G23 VIDEO DETECTOR PROBE

The special video detector probe No. 39G23 has a build in isolation resistor and a video detector, making the SM158 complete for all alignment procedures. The Red lead of the 39G23 has a 27,000 ohm resistor between the Red lead and the input of the SM158 for isolation. The Red lead is connected to the video detector output, or the mixer grid test point on a TV tuner to couple the response curve to the marker adder section of the SM158. The isolation resistor prevents loading the test circuit.

The blue lead of the 39G23 is the input to the video detector. This lead is used when a demodulator probe is required in the alignment procedure such as at the output of the chroma bandpass amplifier for chroma alignment or the output of the tuner for tuner alignment.

OPERATING THE SM158

The operation of the Speed Aligner has been made so simple and easy that it can almost be operated by the average technician without the aid of instructions. The controls have been made self explanitory so that a minimum amount of time is required to get the maximum benefit from the Speed aligner.

Lets look at each control and see how it is used to obtain a response curve from the television receiver.

SWEEP OUTPUT Switch: selects the desired sweeped RF output, IF at 44 MHz, RF at channels 3, 4, 10 and 13 or the special Chroma signal for injection through the IF stages for chroma bandpass alignment. Each signal is fixed so that no hunting around is required, simply flip the switch and get the desired swept frequency.

FINE TUNING Control: Allows the sweep center frequency to be shifted several megahertz each direction. This is to facilitate trap alignment and for checking the skirts on the tuner and IF response curves for trouble shooting.

SWEEP WIDTH Control: is used to vary the width of the swept signal from a few hundred Kilohertz to a full 15 megaherts for full alignment.

SWEEP HEIGHT Control: controls the swept RF output signal level from only a few microvolts to over 250 millivolts or 1/4 of a volt. This level is usefull for forcing signal through a defective receiver or one that has been "touched up" and is way out of alignment.

CRYSTAL CONTROLLED MARKER ADDER Push Buttons: are used to select one or more of the 44 different crystal controlled markers available from the SM158 Speed Aligner. When the SWEEP OUTPUT switch is in the IF position, the marker frequencies indicated in the IF column are available. When the SWEEP OUTPUT switch is in the CHROMA Position, the markers are 4.5, 4.08, 3.58, and 3.08 MHz as required for Chroma alignment.

When the SWEEP OUTPUT switch is set to any one of the four RF channels, the markers automatically become the Adjacent Video trap; sound Carrier, Color Carrier, Video Carrier and Adjacent Sound trap markers; just press the desired button and the correct marker automatically appears.

MARKER HEIGHT Control; serves a dual purpose of controlling not only the height of the markers as seen on the response curve, but has a push pull switch which allows the selection of either regular vertical markers or horizontal markers.

RF OUTPUT TO TV; contains all the swept RF signals for injection through the RF cable to the television receiver.

DETECTOR IN TO TV: jack is where the detected signal from the video detector or output of the chroma bandpass amplifier is fed with the 39G23 detector cable so that the markers may be added to the response curve.

TO SCOPE VERT jack: contains the IF response curve and the marker signals when the MARKER HEIGHT control is pushed in.

TO SCOPE HORIZ jack: has the horizontal sweep signal and also contains the marker signal when the MARKER HEIGHT control is pulled out. If this jack is not used and the regular line sweep of the scope is used to display the response curve, then the horizontal markers will not be visable on the scope screen.

APPLICATIONS

WHAT IS SWEEP ALIGNMENT

A tuned amplifier, such as the IF amplifier in a television receiver, is designed to pass a band of frequencies and reject the frequencies outside of this band. For example a color television IF amplifier is designed to pass frequencies between 41.67 and 46.75 MHz and reject frequencies below 41.25 and above 47.25 MHz. This wide pass band is obtained by having several IF stages each tuned to a different part of the band, i.e.; stagger tuned. Alignment of this amplifier with a standard signal generator is difficult, because each stage has to be aligned individually and then the overall response checked by laboriously recording the output as input frequency is changed in small steps across the band. Plotting output against frequency on a graph would then show the response of the amplifier.

If you were able to tune the frequency of the signal generator at an even rate back and forth across the frequency band of interest you could observe the output (after detection) on an oscilloscope and actually see the response of the amplifier. This is what is done in a sweep generator. The output signal from the generator is a constantly changing frequency over a selected range as determined by tuning and the sweep width settings of the generator. The rate at which the output is swept is low, generally for convenience, the frequency of the AC line.

Markers are added to the response curve to accurately show the frequency at different parts of the curve. They are generated by amplifying the low frequencies on each side of the zero beat that develops when the frequency of the sweep signal passes through the marker oscillator frequency. Generating markers external to the amplifier under test and adding them to the response curve is called post injection. It is superior to a preinjection system where the marker oscillator signal is fed to the amplifier under test along with the sweep signal. Markers developed this way can distort the response curve or are lost in traps making sweep alignment more difficult.

THE COLOR TV IF RESPONSE CURVE

The ideal color TV IF response curve is shown in figure 1. You should become totally familiar with this curve, because it can be an excellent trouble shooting aid. Note that the top of the curve shown is flat. However, some set may have a dip in the top; and others may (newer color sets) have a rounded or "hay stack" top.

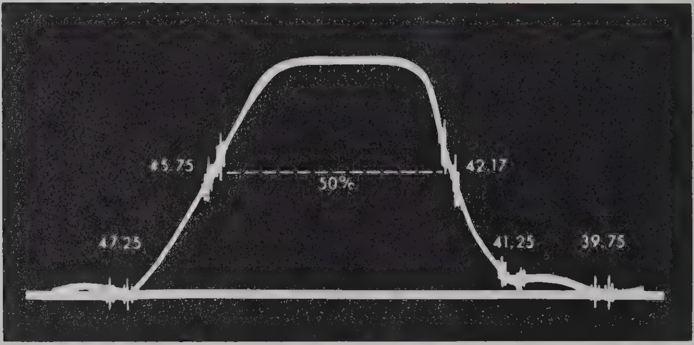


Fig. 1. Ideal Response curve

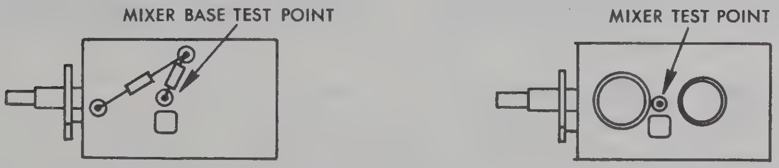
The shape of the response curve skirts is very important. The picture carrier (45.75MHz) and the color sub carrier (42.17MHz) are approximately at the 50 percent points on the skirts. Color signal information 0.5MHz away (41.67) MHz must still pass through the amplifier, but the sound carrier (41.25MHz) must be trapped out so this skirt has a fairly steep slope. The opposite slope is not quite as steep, but should rise linearily for best recovery of low frequency video information. The upper adjacent channel picture carrier (39.75 MHz) and the lower adjacent channel sound carrier (47.25MHz) must be trapped out to prevent interference. The amplifier has minimum or zero gain at these frequencies.

There are a number of things that will affect the response curve. If a trap is misadjusted for example, it will be impossible to get the correct curve and a lot of time can be wasted if this is not recognized. One or more weak stages will also give a poor curve so the tubes should always be checked or substituted before alignment is attempted. The design of an amplifier takes into account the internal tube capacity. When tubes are replaced in an amplifier a different internal capacity could upset the alignment. Study the curve in Figure 1. When you know how the curve should look you will be able to pin-point troubles fast. If tubes are replaced, the set should be "aged" for several hours before realignment is attempted. This will allow the tubes to stabilize.

CONNECTING THE SM158 FOR ALIGNMENT

The SM158 is extremely easy to connect and will require only three cables for the total alignment of a color television receiver, or four if you wish to have horizontal or vertical markers. How to connect these cables is covered in the section below:

RF CABLE: The RF cable is connected to the antenna terminals, the mixer test point in the tuner, or to the individual IF stages depending on the alignment instructions of the particular manufacturer. The 39G22A matching pad is used in most cases as it not only acts as a 300 ohm match for the antenna terminals found on the TV set, but terminates the cable so that no standing waves are present. When using the RF frequencies of channel 3 and above, the RF cable is connected to the antenna terminals of the set using the red and green leads. If TV IF alignment is being performed, the RF cable with the 39G22A matching pad connected is either connected to the mixer test point or capacity coupled to the mixer tubes with the red lead, and the black lead to ground. The test point is easy to find as it is generally located next to a square hole in the tuner. Figure 2 shows this location on a tube and transistor tuner. On some solid state tuners, the test point is on top of the tuner as in the tube model, and in others it maybe located on the side of the tuner.



TYPICAL TRANSISTOR TUNER
TEST POINT LOCATION

TYPICAL TUBE TYPE TUNER
TEST POINT LOCATION

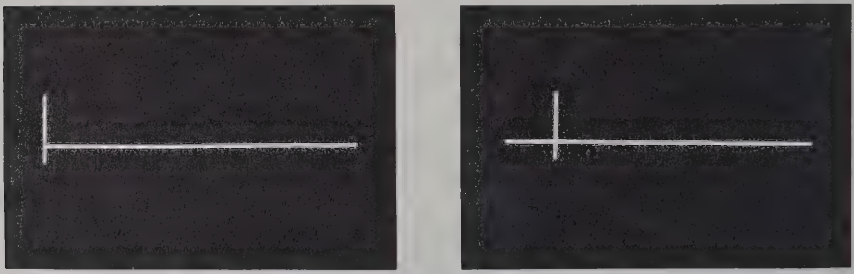
FIGURE 2

To capacity couple to the mixer tube, you can use an ungrounded tube shield or use a conductive foil wrapped around the mixer tube when the shield is not removable. The foil should be covered with tape to prevent it shorting to the shield. In either case the red lead of the 39G22A matching pad is connected to the shield or foil and the black lead to ground. When injecting the signal into individual IF stages, a .001 disc capacitor should be placed in series with the red lead of the 39G22A. The 39G22A matching pad is not used when matching into 75 ohm systems.

The DETECTOR CABLE is connected from the SM158 DETECTOR IN jack to the various points as described in the individual alignment procedures that follow.

The SCOPE Vertical input cable is connected from the SCOPE VERT jack on the SM158 to the vertical input of the scope.

The SCOPE HORIZ jack is connected to the horizontal input of the scope and the scope selecter switch set to EXTERNAL.



Correct Phase Adjustment

Incorrect Phase Adjustment

FIGURE 3

PHASE ADJUSTMENT

The PHASE ADJ found on the rear of the Speed Aligner is normally set once for the scope you use and then not touched again unless the scope is changed. The phase adjustment can be checked very easily by observing the trace on the scope without any signal input to the DETECTOR IN jack. Figure 3 shows the in-phase condition and the out of phase condition. Note the spike on the curve should appear at the extreme end of the horizontal base line for proper phase adjustment. If not, then the scope and Speed Aligner are out of phase and distortion of the response curve can result.

DETERMINING THE ACCURACY OF THE SCOPE FOR SWEEP ALIGNMENT

The oscilloscope is an important tool in sweep alignment. If the scope does not have a good low frequency response, has a phase shift in the vertical amplifier, or a phase shift between the horizontal and vertical amplifier, the response curve on the scope screen can be misleading as to the actual condition of the television receiver. Any of the above conditions can distort the response curve enough to give inaccurate results when the TV set is aligned. The Sencore SM158 has an ultra linear sweep and a flat output that can be used to check out the scope before any alignment is started. If the scope is checked out, the results can be taken into consideration when doing the alignment for a more precise job.

To make the accuracy check with the SM158 on your scope, follow these steps:

1. Set the SM158 to IF and maximum RF output.

2. Connect the RF cable using the red lead of the matching pad to the detector probe blue lead, black lead to black lead, and the scope vertical input to the SCOPE VERT jack on the SM158.

3. Adjust the scope vertical gain until a usable pattern is seen. If the scope is good and has no phase shift and has a good low frequency response, the pattern should appear as shown in figure 4

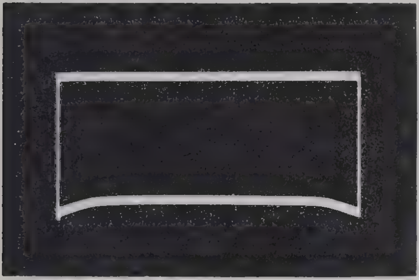


Fig. 4 Flat scope response

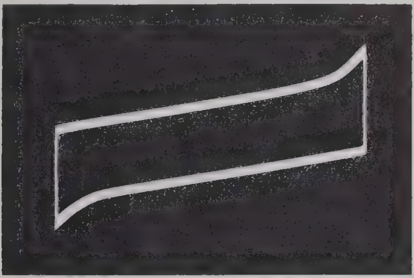


Fig. 5 Poor vertical low frequency response

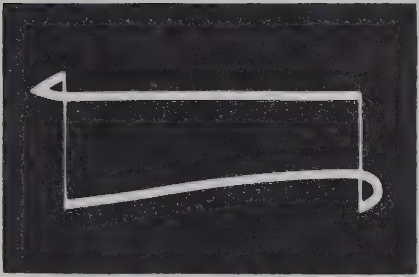


Fig. 6 Phase shift in the horizontal amplifier

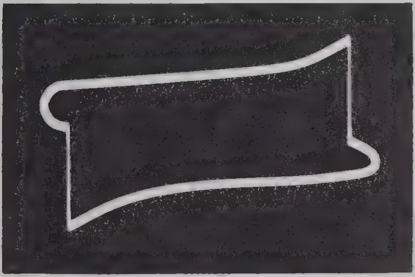


Fig. 7 Phase shift and poor low frequency response

If the scope has a poor low frequency response, the pattern will appear as shown in figure 5. The more the pattern bows or tilts the worse the low frequency response is. Some bowing or tilting of the pattern will be acceptable and should be taken into consideration when adjusting the television receiver. Figures 6 and 7 show other various scope troubles. If any of these problems appear to excess, it will affect the response curve of the TV set.

OVERALL ALIGNMENT CHECK WITH THE SM158

An overall alignment check should be made when the alignment of the television receiver is in question, or as a general procedure to insure your customer the best possible picture. The overall procedure outlined below will check the tuner and IF amplifiers from the antenna terminals to the video detector. If there is any misalignment or other troubles, they will show up on this check. Connect as shown in figure 8.

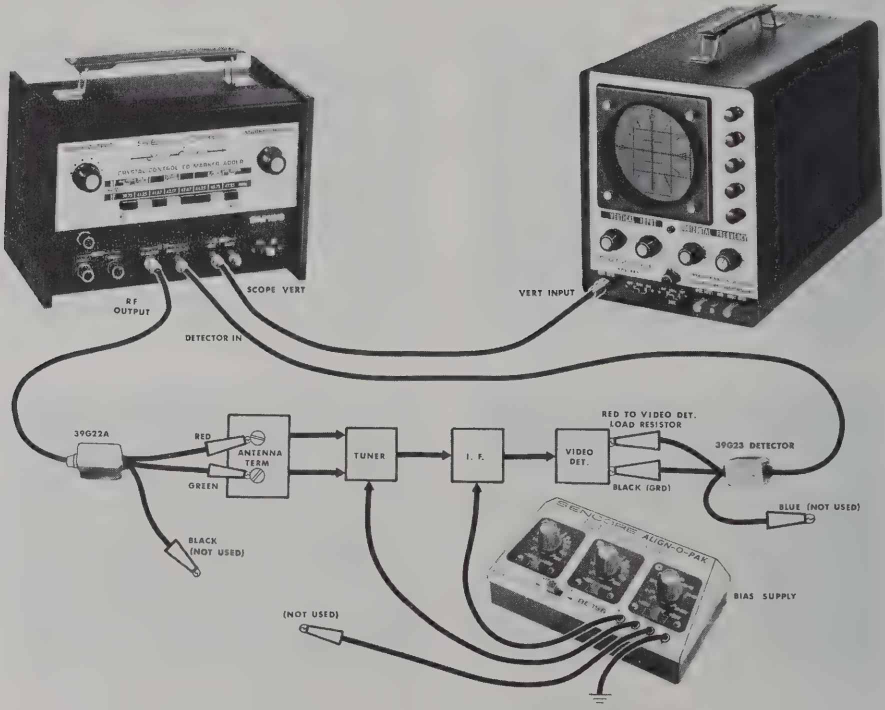

RF OUTPUT
SCOPE VERT
VERT INPUT
DETECTOR IN
39G22A
RED
ANTENNA TERM
GREEN
BLACK (NOT USED)
TUNER
I. F.
VIDEO DET.
RED TO VIDEO DET. LOAD RESISTOR
39G23 DETECTOR
BLACK (GRD)
BLUE (NOT USED)
SENCORE ALIGN-O-PAK
BIAS SUPPLY
(NOT USED)

Fig. 8 Connecting for overall alignment check

To make the overall alignment check with the SM158 proceed as follows:

1. Connect the RF cable terminated with the 39G22A matching pad from the SM158 RF OUT jack to the antenna terminals of the television receiver.
2. Set the SM158 Range switch to channel 10. Set the TV tuner to Channel 10 also.
3. Connect the 39G23 detector probe Red lead to the video detector load resistor or the grid of the first video amplifier. In many TV receivers, there is a terminal at the top of the chassis for the detector and AGC test point. The other end of the detector cable should be connected to the DETECTOR IN jack on the front panel of the SM158.
4. Apply a bias to the IF and tuner AGC test points. Some manufacturers recommend shorting the IF AGC ground. Be sure to check the manufacturers literature. A negative two volt bias is used on the tuner in tube receivers. Solid state receivers use positive or negative bias depending on the type of transistor used and if forward or reverse AGC is used.
5. Connect the scope vertical input to the SCOPE VERT jack on the front panel and the scope horizontal input to the SCOPE HORIZ jack on the front panel. The scope vertical sensitivity should be set so that a two volt peak to peak signal will give two inches of vertical deflection. A two volt signal from the video detector is a good average output to maintain during the alignment.
6. Set the RF OUTPUT control until you have a 2" response curve.
7. Depress the Video carrier marker button and adjust the fine tuning control of the television receiver until the marker rests on the 50% point of the response curve as shown in figure 9. Depress the color carrier marker button. The marker should fall at the 50% point on the opposite end of the curve as shown in figure 9.

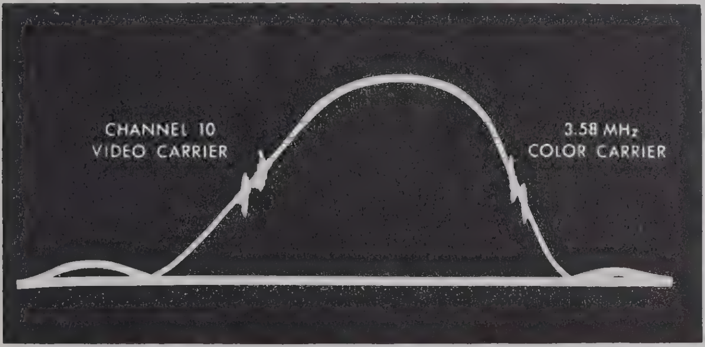


Fig. 9 Overall response curve

If the overall response curve is not as shown in figure 9, then the television receiver is in need of alignment. The stages that are most likely to be off are the IF amplifiers. If the overall alignment is off, proceed with the IF alignment check.

IF RESPONSE CURVE CHECK

The IF amplifiers of the television receiver are the most critical amplifiers in the set. Most of the variations of the overall response curve will be the result of changes in the IF amplifiers. Tube capacity differs from tube to tube and transistor to transistor, so that when a new tube or transistor is replaced in the IF, the response curve will change. To make a quick check of the IF response, follow these simple steps:

1. Connect the 39G22A matching pad red lead to the mixer test point or capacity couple into the mixer tube as described in "CONNECTING THE SM158 FOR ALIGNMENT". Connect the Black lead to ground.
2. Connect the red lead of the 39G23 detector probe to the video detector load resistor or input of the first video amplifier. Connect the black lead to ground.
3. Connect the scope vertical input to the SCOPE VERT jack on the front panel of the SM158 and the scope Horiz input to the SCOPE Horiz jack.
4. Connect a bias supply to the IF AGC test point. If you do not have a schematic, follow the grid load resistor and connect the negative lead of the supply to the end of this resistor. If the IF is solid state, find the base resistor and connect a negative bias supply to the end opposite the base end. In tube receivers, a negative 2 to 3 volts is normally used, and in solid state receivers a positive voltage will be normal. The amount of voltage should be taken from the service literature.
5. Set the VHF tuner to a high channel such as 13.
6. Set the SM158 Range switch to IF, and the SWEEP WIDTH control until all 8 markers are visible on the scope screen.
7. Adjust the SWEEP HEIGHT control until you have a 2 volt peak to peak response curve.
8. Depress the 45.75 and the 42.17 markers and adjust the MARKER HEIGHT control until the markers are to your liking.

The response curve should appear as shown in figure 9. Note that the curve may be a flat topped curve and that some of the later model sets will have a "Haystack" or rounded top curve. In both cases, the video and color carriers should fall at about the 50% points on the curve for the best alignment. You can depress the trap and color sideband limit markers at this time so that all eight markers a visable on the curve. The traps should be on the baseline indicating minimum gain and the color sideband limits should falls as shown in figure 10.

UHF SWEEP OUTPUT WITH THE SM158 SPEED ALIGNER

After a receiver has been adjusted for overall IF response, a check should be made to determine whether or not the UHF and VHF tuners have the proper bandpass and response. These checks should be made to eliminate the possibility of a defective or misaligned tuner creating additional problems. The UHF and VHF RF/IF overall response check will also provide a quick and efficient means of isolating the tuner as a source of problems in a receiver being serviced. The VHF RF/IF overall response check procedures are given on Page 12 of the SM158 Service Manual.

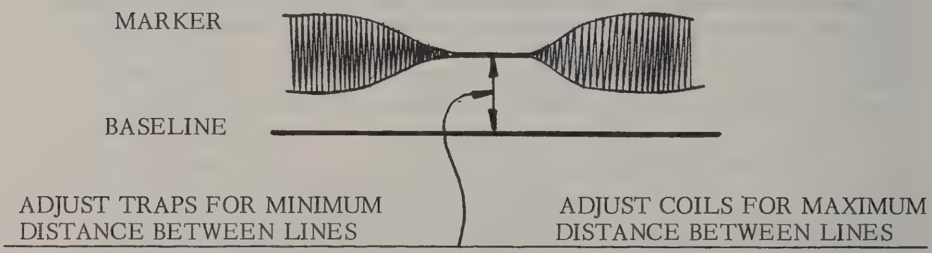
Although not specifically called out by a front panel switch position, a UHF sweep output is also available at the RF output jack. To obtain this output, it is only necessary to position the Sweep Output switch in the IF position. Connections for the UHF RF/IF overall response check are the same as shown in Figure 8 of the Service Manual except for the RF cable and 300 ohm matching pad. The connection for the RF cable and pad is made to the UHF antenna terminals of the receiver or directly to the input terminals of the UHF tuner. Tune the UHF tuner to channel 41. (The exact setting of the UHF tuner will vary somewhat depending on the accuracy of the channel indicator associated with the UHF tuner.) The overall response curve should be similiar to the IF overall response curve or the curve shown in Figure 9 of the Service Manual.

SENCORE
NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT
3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

IF SPOT-ALIGNING WITH THE SM158 SPEED ALIGNER

In many cases the receiver to be aligned will be badly mid-aligned due to component changes or someone tampering with the adjustment. To facilitate the alignment of this receiver, the coils and traps can be preset near their correct alignment point by "spot-aligning." Spot-aligning is nothing more than adjusting each coil for maximum response at its specified operating frequency and adjusting the traps for minimum response. A single frequency RF generator or equivalent is necessary to perform the spot-alignment.

The following procedure will allow spot-alignment using the SM158. The SM158 connections will be the same as for IF alignment given on page 14 of the Service Manual. Depress the marker push button of the frequency to be used for coil or trap adjustment. While observing the response of the oscilloscope, adjust the Sweep Width to minimum (counterclockwise rotation) keeping the marker in the center of the scope display by adjusting the SM158 Fine Tuning Control. The display obtained should appear as illustrated below.


MARKER
BASELINE
ADJUST TRAPS FOR MINIMUM DISTANCE BETWEEN LINES
ADJUST COILS FOR MAXIMUM DISTANCE BETWEEN LINES

This procedure will provide on RF output signal, without sweep, at the exact frequency of the crystal marker. To set traps, follow the above procedure using marker corresponding to the trap frequency and adjust the trap to reduce the spacing between the two horizontal lines to minimum. (See illustration) When setting traps, increase Sweep Output as separation between lines decreases. To peak coils, follow the above procedure using the marker corresponding to the coil frequency and adjust for maximum separation between horizontal lines. (see illustration) When peaking coils, maintain a low level of Sweep Output so that the receiver does not become overloaded. In the event that a marker is not available at the exact frequency, use the closest marker frequency available. After spot-alignment, proceed with the overall IF alignment.

Addendum for SM152 and SM158 Service Manuals

Subject: 39G47 Adapter Cable

An adapter cable is now available to allow easy connection of the Scope Vertical and Horizontal output jacks of your Sencore Sweep/Marker generator to any oscilloscope having a BNC input jack. The 48 inch BNC to phono plug adapter cable is equipped with a standard phono plug on one end to mate with the Scope output jacks of the Sencore Sweep/Marker generators. The other end has a BNC connector to mate with the BNC jack of the Sencore PS163 Dual Trace Triggered Sweep oscilloscope or other oscilloscopes having a BNC input.

The part number for this adapter cable is 39G47 and is available from the Sencore Service Department serving your region for $8.00.

Sencore Eastern
Sales & Service
4105 Duke Street
Alexandria, Virginia
22304
A/C703-751-3556

Sencore Central
Sales & Service
2711 B Curtis St
Ellsworth Ind. Park
Downers Grove, Ill.
60515
A/C312-852-6800

Sencore Western
Sales & Service
3200 Sencore Drive
Sioux Falls, So.Dak.
57107
A/C605-339-0100

THE IDEA PEOPLE

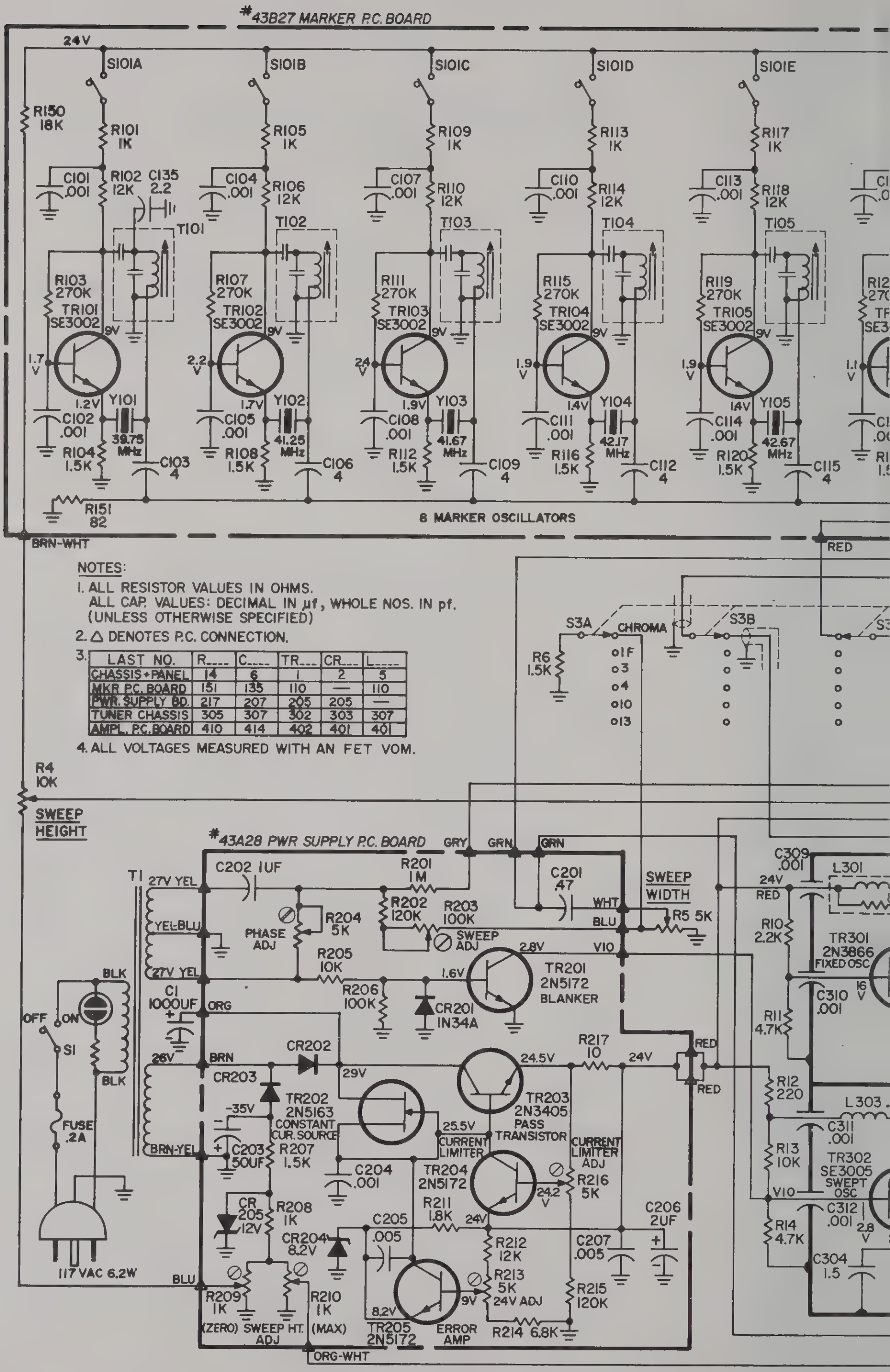
SENCORE
3200 Sencore Drive Sioux Falls, South Dakota 57107

FORM 702

SCHEMATIC AND PARTS LIST
FOR
SM158

Speed Aligner

REFERENCE NO.	PART NO.	DESCRIPTION	PRICE
CONTROLS			
R1 & S2	15B6-2	20K pot w/push pull switch	1.90
R3	15C1-11	2K bushing mt. carbon	1.50
R4	15C-15	10K bushing mt. carbon	1.50
R5	15C1-22	5K bushing mt. carbon	1.50
R144, 145, 213, 216	15C7-14	5K VERT P.C. MT.	.75
R148	15C7-2	10K VERT P.C. MT	.75
R203	15C7-13	100K VERT P.C. MT	.75
R204	15C7-16	5K HORIZ P.C. MT.	.75
R209, 210	15C7-17	1K VERT P.C. MT.	.75
SEMICONDUCTORS			
TR1, 402	19C7-1	SE3002 TRANSISTOR	1.50
TR101 thru TR108	19C7-1 or 19C15-1	SE3002 or 2SC684 TRANSISTOR	1.50
TR109, 110, 201, 204, 205	19C4-1	2N5172 TRANSISTOR	.50
TR202	19C6-1	2N5163 FET	1.50
TR203	19C10-1	2N3405 TRANSISTOR	2.00
TR301	19C13-1	2N3866 TRANSISTOR	4.00
TR302	19C7-2	SE3005 TRANSISTOR	1.50
TR401	19C2-1	3N140 MOSFET	4.50
CR201	50C3-1	DIODE, 1N34A	.50
CR202, 203	16S10	RECTIFIER 1AMP 400P1V	1.50
CR204	50C4-2	ZENER DIODE, 8.2V, 1W	1.35
CR205, 401	50C4-3	ZENER DIODE, 12V, 1W	1.35
CR301	50C11-1	DIODE, VARICAP, BA141	4.00
CR302	50C6-1	DIODE, VARICAP, MV1620	3.00
CR303	50C3-3	DIODE, 1N82A	1.50
	50C3-4	DETECTOR DIODE 1N774	.75



#43B27 MARKER P.C. BOARD
24V
S101A
S101B
S101C
S101D
S101E
R150 18K
R101 1K
R105 1K
R109 1K
R113 1K
R117 1K
C101 .001
R102 12K
C135 2.2
C104 .001
R106 12K
C107 .001
R110 12K
C110 .001
R114 12K
C113 .001
R118 12K
T101
T102
T103
T104
T105
R103 270K
TR101 SE3002
R107 270K
TR102 SE3002
R111 270K
TR103 SE3002
R115 270K
TR104 SE3002
R119 270K
TR105 SE3002
9V
1.7 V
2.2 V
24 V
1.9 V
1.9 V
1.1 V
1.2V
1.7V
1.9V
1.4V
1.4V
Y101 39.75 MHz
Y102 41.25 MHz
Y103 41.67 MHz
Y104 42.17 MHz
Y105 42.67 MHz
C102 .001
C105 .001
C108 .001
C111 .001
C114 .001
R104 1.5K
R108 1.5K
R112 1.5K
R116 1.5K
R120 1.5K
C103 4
C106 4
C109 4
C112 4
C115 4
R151 82
8 MARKER OSCILLATORS
BRN-WHT
RED
S3A
CHROMA
S3B
R6 1.5K
1F
3
4
10
13
R4 10K
SWEEP HEIGHT
#43A28 PWR SUPPLY P.C. BOARD
GRY
GRN
GRN
T1
27V YEL
YEL-BLU
27V YEL
C202 1UF
R201 1M
R202 120K
R203 100K
PHASE ADJ
R204 5K
SWEEP ADJ
R205 10K
R206 100K
C201 .47
WHT
BLU
SWEEP WIDTH
R5 5K
VIO
2.8V
1.6V
TR201 2N5172 BLANKER
CR201 1N34A
C309 .001
24V RED
L301
R10 2.2K
TR301 2N3866 FIXED OSC
C310 .001
16 V
R11 4.7K
BLK
OFF
ON
S1
BLK
FUSE .2A
117 VAC 6.2W
C1 1000UF
ORG
26V
BRN
CR202
29V
CR203
-35V
TR202 2N5163 CONSTANT CUR. SOURCE
C203 50UF
R207 1.5K
BRN-YEL
TR203 2N3405 PASS TRANSISTOR
24.5V
R217 10
24V
RED
RED
25.5V
CURRENT LIMITER
CURRENT LIMITER ADJ
R216 5K
C204 .001
TR204 2N5172
24.2 V
R12 220
L303
C311 .001
R13 10K
TR302 SE3005 SWEPT OSC
VIO
C312 .001
2.8 V
R14 4.7K
C304 1.5
CR 205 12V
R208 1K
C205 .005
R211 1.8K
24V
CR204 8.2V
R212 12K
C207 .005
C206 2UF
BLU
R209 1K
R210 1K
(ZERO) SWEEP HT. ADJ
(MAX)
8.2V
TR205 2N5172
9V
ERROR AMP
R213 5K 24V ADJ
R215 120K
R214 6.8K
ORG-WHT

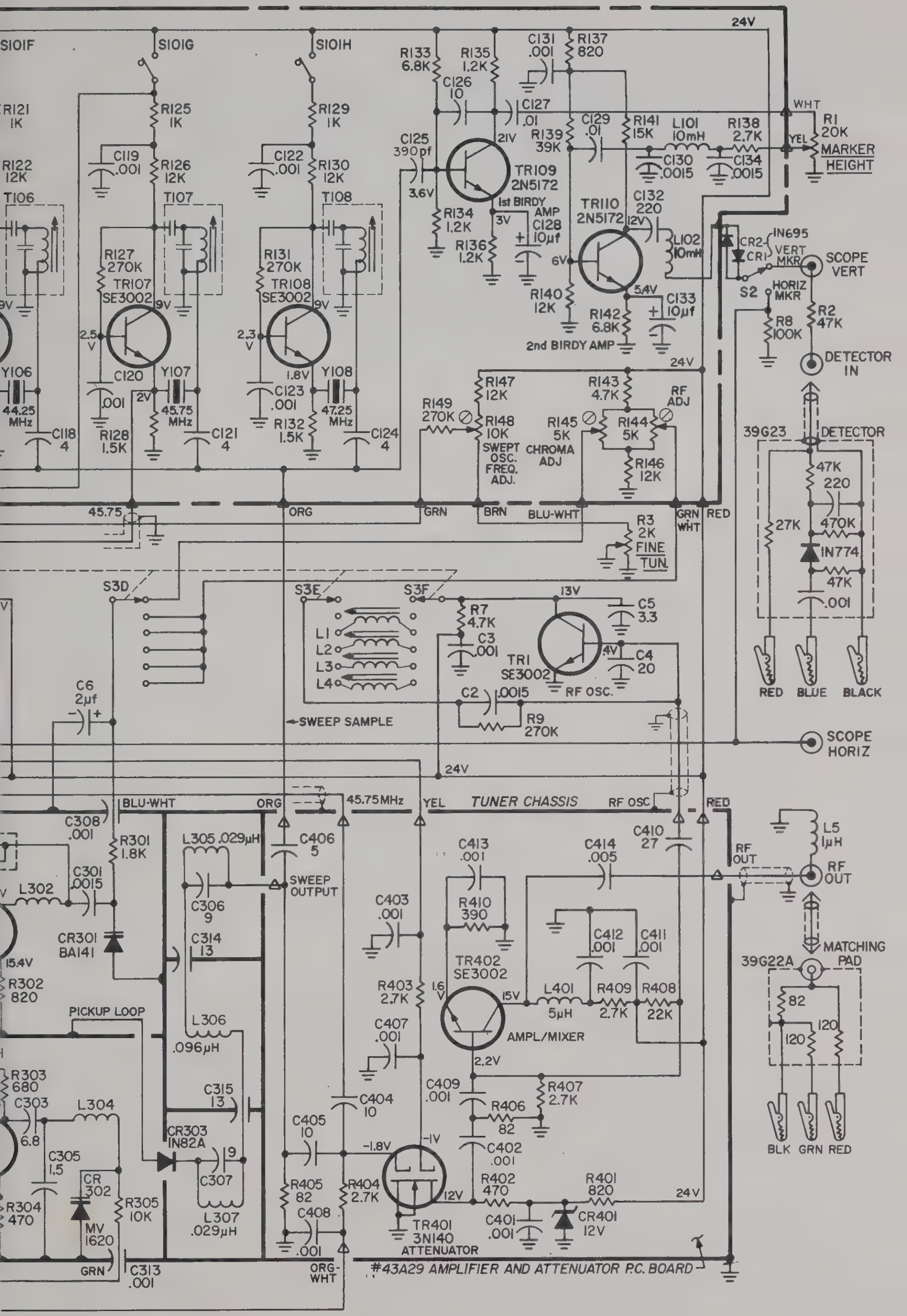
NOTES:

1. ALL RESISTOR VALUES IN OHMS.
ALL CAP. VALUES: DECIMAL IN μf, WHOLE NOS. IN pf.
(UNLESS OTHERWISE SPECIFIED)
2. △ DENOTES P.C. CONNECTION.
3.

LAST NO.	R____	C____	TR____	CR____	L____
CHASSIS+PANEL	14	6	1	2	5
MKR P.C. BOARD	151	135	110	—	110
PWR. SUPPLY BD.	217	207	205	205	—
TUNER CHASSIS	305	307	302	303	307
AMPL. P.C. BOARD	410	414	402	401	401

4. ALL VOLTAGES MEASURED WITH AN FET VOM.

SM158 'SPEED ALIGN



SIOIF
SIOIG
SIOIH
24V
R121 1K
R122 12K
T106
R125 1K
C119 .001
R126 12K
T107
R127 270K
TR107 SE3002
9V
2.5 V
C120 .001
2V
Y106 44.25 MHz
Y107 45.75 MHz
C118 4
R128 1.5K
C121 4
R129 1K
C122 .001
R130 12K
T108
R131 270K
TR108 SE3002
9V
2.3 V
1.8V
Y108 47.25 MHz
C123 .001
R132 1.5K
C124 4
R133 6.8K
R135 1.2K
C126 10
C127 .01
C125 390pf
3.6V
21V
TR109 2N5172
1st BIRDY AMP
R134 1.2K
3V
R136 1.2K
C128 10µf
C131 .001
R137 820
C129 .01
R139 39K
R141 15K
L101 10mH
R138 2.7K
C130 .0015
C134 .0015
WHT
YEL
R1 20K
MARKER HEIGHT
TR110 2N5172
C132 220
12V
L102 10mH
6V
5.4V
R140 12K
R142 6.8K
C133 10µf
2nd BIRDY AMP
CR2 IN695
CR1
VERT MKR
HORIZ MKR
S2
SCOPE VERT
R2 47K
R8 100K
DETECTOR IN
24V
R147 12K
R149 270K
R148 10K
SWEPT OSC. FREQ. ADJ.
R143 4.7K
RF ADJ
R145 5K
CHROMA ADJ
R144 5K
R146 12K
39G23
DETECTOR
47K
220
27K
470K
IN774
47K
.001
RED
BLUE
BLACK
45.75
ORG
GRN
BRN
BLU-WHT
GRN WHT
RED
R3 2K FINE TUN.
S3D
S3E
S3F
L1
L2
L3
L4
R7 4.7K
C3 .001
13V
C5 3.3
4V
C4 20
TR1 SE3002
RF OSC.
C2 .0015
R9 270K
C6 2µf
SWEEP SAMPLE
SCOPE HORIZ
24V
BLU-WHT
ORG
45.75MHz
YEL
TUNER CHASSIS
RF OSC
RED
C308 .001
R301 1.8K
L305 .029µH
C406 5
SWEEP OUTPUT
C301 .0015
L302
C306 9
CR301 BA141
C314 13
15.4V
R302 820
PICKUP LOOP
L306 .096µH
R303 680
C303 6.8
L304
C315 13
C305 1.5
CR 302
MV 1620
R305 10K
CR303 IN82A
C307 9
L307 .029µH
R304 470
GRN
C313 .001
C413 .001
R410 390
C403 .001
C410 27
C414 .005
RF OUT
L5 1µH
RF OUT
MATCHING PAD
39G22A
82
120
120
BLK
GRN
RED
C412 .001
C411 .001
TR402 SE3002
1.6 V
15V
L401 5µH
R409 2.7K
R408 22K
R403 2.7K
AMPL/MIXER
C407 .001
2.2V
C409 .001
R407 2.7K
R406 82
C404 10
C405 10
-1.8V
-1V
C402 .001
R402 470
R401 820
24V
R405 82
R404 2.7K
12V
C408 .001
TR401 3N140 ATTENUATOR
C401 .001
CR401 12V
ORG-WHT
#43A29 AMPLIFIER AND ATTENUATOR P.C. BOARD

R' SCHEMATIC

ISSUE DATE: 8-24-70

CAPACIATORS

C1	24G129	1000vfd@40V LYTIC	2.00
C201	24G222	.47ufd@100V POLY	.60
C202	24G160	1utd@200V MYLAR	.65

SWITCHES

S1	25G124	DPDT LIGHTED SLIDE	1.50
S2	(PART OF R1 CONTROL)		
S3	25A140	6P6P ROTARY	4.00
S101	25B118-2	8 SECTION PUSH/PUSH SWITCH	10.00

CRYSTALS

Y101	47G9	39.75 MHz CRYSTAL	5.00
Y102	47G10	41.25 MHz CRYSTAL	5.00
Y103	47G11	41.67 MHz CRYSTAL	5.00
Y104	47G12	42.17 MHz CRYSTAL	5.00
Y105	47G13	42.67 MHz CRYSTAL	5.00
Y106	47G14	44.25 MHz CRYSTAL	5.00
Y107	47G7	45.75 MHz CRYSTAL	6.00
Y108	47G15	47.25 MHz CRYSTAL	5.00

MISCELLANEOUS

	26G114	75 ohm COAX JACK	1.00
TR101 thru TR108	28C28	40MHz TRANSFORMER	1.50
	28C42	POWER TRANSFORMER	6.00
L1, 2	46A30	CHANNEL 3 & 4 RF COIL	.75
L3, 4	46A48	CHANNEL 10 & 13 RF COIL	.75
L5	46G19	1uH CHOKE	.30
L101, 102	46G19	10mH CHOKE	1.00
L301	46A49	RF CHOKE ON 8.2K	.30
L303	46A26	.17uH CHOKE	.30
L305, 307	46A37	.029 uH CHOKE	.30
L306	46A38	.096uH CHOKE	.30
L401	46G6	6uH CHOKE	.30
	SC8B40	FRONT PANEL	7.00
	SC8B41	ESCUTCHEON	3.00
	10B257	TUNER COVER	1.00
		CASE COMPLETE	16.00
		RF CABLE	1.50
	39G23	DETECTOR CABLE	7.95
	39G22A	MATCHING PAD	5.95

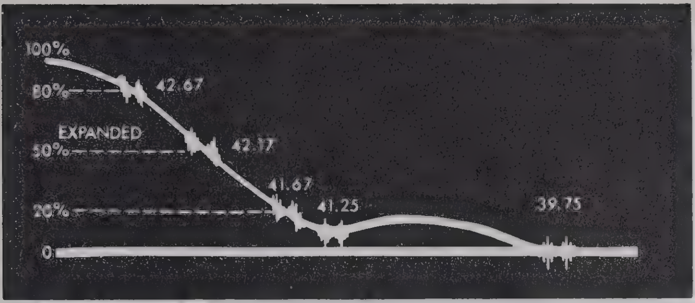


Fig. 10 Color slope of response curve

EASY TRAP ADJUSTMENT

You can increase the gain of the vertical scope amplifier and reduce the sweep width to about that shown in figure 10. This will allow you to observe the action on the trap coil as you adjust it. Simply place the marker in the dip for minimum gain at the trap frequency. This is the fastest and most accurate method of trap alignment in the color receiver.

Each manufacture has a different method of alignment for his particular television receiver. It is best to follow these alignment instructions for the proper test points and order of alignment. Above all, be sure the traps are properly set before alignment of any of the IF transformers are under taken. This will insure you getting the proper alignment curve in the shortest time.

INTERFERENCE ON THE RESPONSE CURVE

Hash and interference on the response curve can be caused by both the horizontal output circuit and the vertical output circuit radiating. The horizontal output tube will cause a hash or grass on the overall curve as shown in figure 11 while the vertical circuit will cause a spike to drift through the response curve and cause distortion. The following describes how each type of interference can be eliminated.

Horizontal Output Tube Radiation: One of the easiest ways to remove the horizontal output radiation is to remove the horizontal output tube from its socket. Do NOT merely take the cap off, because in some circuits, the screen of the output tube will be destroyed. In a series string type receiver, it is very difficult to take the tube out without disrupting the entire set, unless a dummy tube or resistor is put in its place. A very handy and easy way is to use the Sencore RC146, Handy 75, power resistor section of 20 values at 20 watts and connect the output of this section across the filament pins of the tube socket. If it is compactron, the filament pins are 1 and 12 and if it is a novar, pins 4 and 5. There may be a tube or two with variations of this, but these are the most common filament pins. Consult a tube manual or the set schematic if in doubt. With the Handy 75 connected to

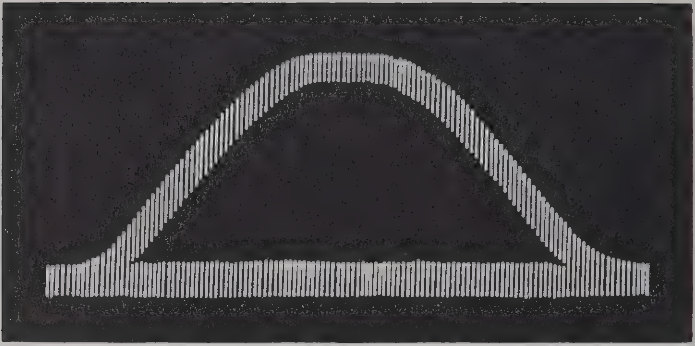


FIGURE 11 HORIZONTAL INTERFERENCE CAUSE BY OUTPUT TUBE

the filament pins, connect a volt meter across the filament pins and adjust the selector switch with the TV set on to provide a voltage drop equal to the filament voltage of the tube that was removed.

Vertical Circuit Interference: Interference from the vertical circuits is generally a spike that will drift through the response curve and cause distortion as it passes through. This is created because of the slight difference in frequency between the vertical frequency of the set and that of the sweep generator. In many cases, the vertical hold control can be adjusted to lock the spike in at the end of the response curve where it is out of the way. Some sets have a "set up" switch. This switch can be used to disable the vertical deflection system, eliminating the vertical interference.

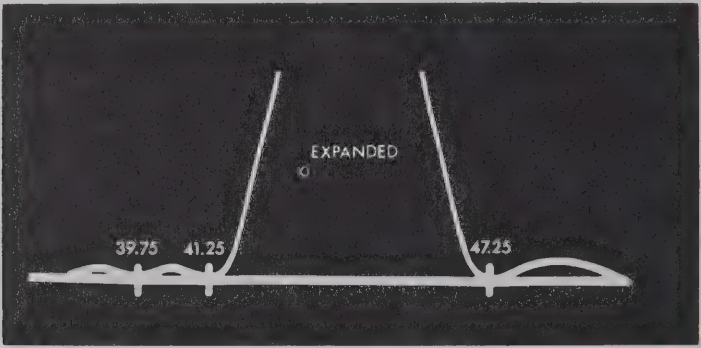


FIGURE 12 LOCATION OF TRAPS ON RESPONSE CURVE

A good point to remember is to use the video and color carrier markers when making the touch up adjustments. If you do this, you will be sure that you are not shifting the carrier points above or below their respective 50 percent points on the curve.

CHROMA BANDPASS ALIGNMENT

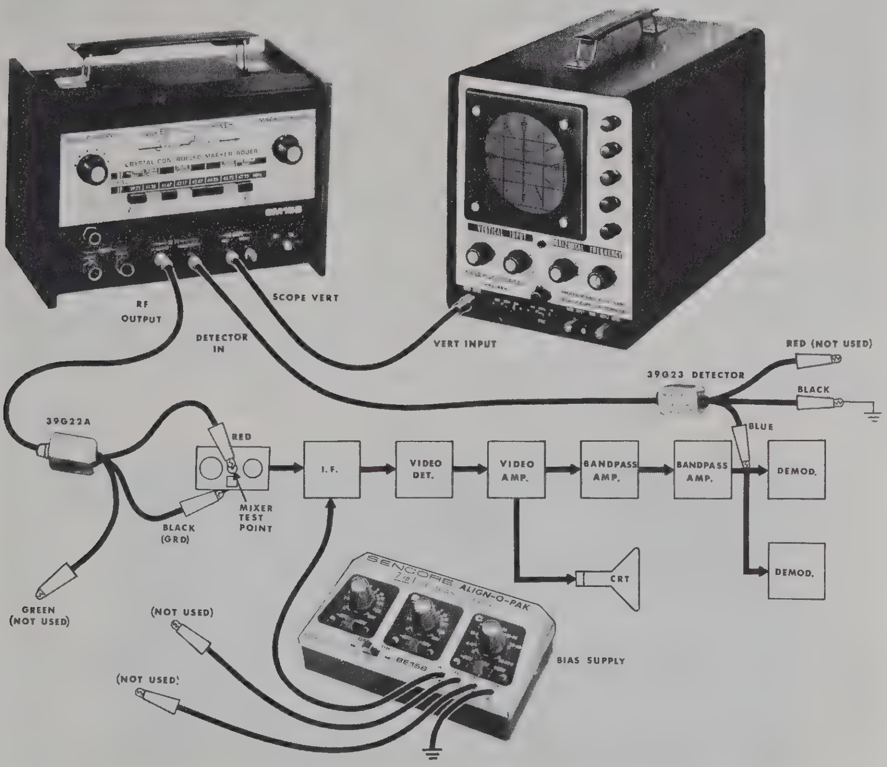

CRYSTAL CONTROLLED MARKER ADDER
VERTICAL INPUT
HORIZONTAL FREQUENCY
RF OUTPUT
SCOPE VERT
DETECTOR IN
VERT INPUT
RED (NOT USED)
39G23 DETECTOR
BLACK
BLUE
39G22A
RED
I. F.
VIDEO DET.
VIDEO AMP.
BANDPASS AMP.
BANDPASS AMP.
DEMOD.
MIXER TEST POINT
BLACK (GRD)
DEMOD.
CRT
GREEN (NOT USED)
(NOT USED)
SENCORE ALIGN-O-PAK
BE158
BIAS SUPPLY
(NOT USED)

FIGURE 13

CONNECTING FOR BANDPASS ALIGNMENT THROUGH THE VIDEO IF

Color signal information is amplified unequally as it passes through the IF amplifier, because the color subcarrier is at the 50 percent point on the response curve skirt. The bandpass amplifier must make up for this condition by amplifying the color signal information unequally in the opposite direction, so that the net effect is equal amplification of the entire color signal. The only way that the bandpass amplifier can be aligned easily is to feed a special signal through the IF and observe the bandpass response at the output of the bandpass amplifier. See Figure 13. The SM158 provides this necessary signal when the SWEEP OUTPUT switch is set to CHROMA.

NOTE: It is very important that the IF response is aligned first, because good alignment of the bandpass amplifier depends on proper IF alignment.

After the IF has been aligned or checked, simply turn the SWEEP OUTPUT switch to the CHROMA position and connect the Blue lead of the 39G23 detector probe to the output of the bandpass amplifier and you are set to check out and align the chroma section of the receiver. Follow these simple steps:

1. Connect the 39G22 matching pad to the tuner test point (see figure 2) or capacity couple to the mixer tube as described in CONNECTING THE SM158 FOR ALIGNMENT.
2. Connect the Blue lead of the 39G23 detector probe to the output of the bandpass amplifier, or to the cathode of one of the demodulators, and the Black lead to ground.
3. Connect a bias supply to the IF AGC test point. A positive voltage is needed if the set is solid state and negative voltage for a tube set. In some cases, the manufacturer will tell you to ground out the AGC test point in a tube receiver. This also will hold true for the chroma alignment.
4. Set the TV receiver to a high channel such as 13.
5. Set the Sweep Height control on the SM158 as you would for IF alignment. A two volt peak to peak response curve is normal with most sets.
6. The scope vertical input should now be connected to the SCOPE VERT jack on the SM158 and the scope horizontal input to the SCOPE HORIZ jack.

The best procedure for alignment of the chroma is to follow the manufacturer's service procedure. The overall curve should appear as shown in figure 14.

Note that the 3.08 and 4.08 markers should be equally spaced and appear near the 80% points on the curve. In many sets, an automative 3.58 marker may appear on the curve due to the 3.58 crystal in the set.

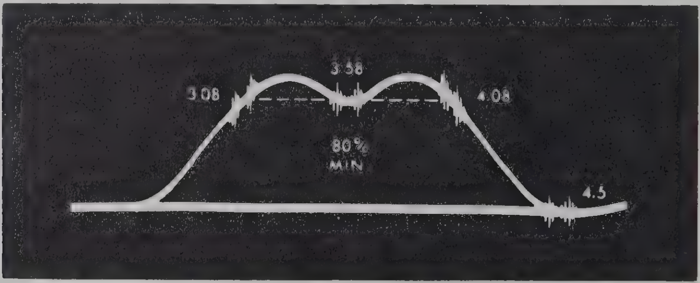


FIG. 14 CHROMA BANDPASS CURVE THROUGH IF

In most cases, the chroma take off coil is peaked at 3.58MHz for maximum gain while the second and third transformers will affect the 3.08 and 4.08 marker positions on the curve respectively. This will not always hold true, so check the manufacturers literature for their recommended procedure.

SPECIAL NOTE: when doing chroma alignment depress only the 4.5, 4.08, 3.58, and 3.08MHz marker buttons. The other markers may cause a slight beat effect on the response curve. This in no way effects the curve, but may become annoying to the technician. The 3.58MHz marker may also beat with the internal crystal in the television receiver. This can be eliminated by turning the 3.58MHz marker button off. The crystal in the television receiver will produce a 3.58 marker automatically on the response curve.

AFT ALIGNMENT (automatic fine tuning)

With many of the newer color sets having automatic fine tuning circuits, alignment will be necessary as the circuit ages and drifts or a componant is changed.

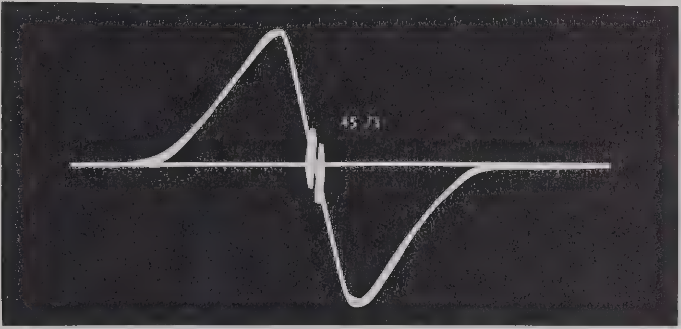


Fig. 15 AFT "S" Curve

The connections for AFT alignment are identical to those of IF alignment except the 39G23 detector probe is connected to the output of the AFT circuit and not the video detector. It is best to follow the manufacturers alignment procedure here for best results. Basicly, the resultant curve is an "S" curve. The 45.75MHz video carrier must be positioned on the cross over point with equal symmetry above and below for best pull in. The peaks of the "S" curve will be about 1 to 1.5MHz above and below the 45.75MHz video carrier. See figure 15 for typical AFT "S" curve.

FINDING MARKER POINTS OTHER THAN THOSE PROVIDED

The Sencore SM158 has eight crystal controlled markers available to cover all the major points on the response curve. There are times however, that markers other than those provided may be desired for various reasons. The SM158 sweep is so linear that the different marker points can be approximated on the scope screen with ease. For most alignment work, this method is fast and easy. If greater accuracy is desired, the following method can be used to calibrate the horizontal trace for exact frequency points.

Connect the SM158 to the oscilloscope without any signal going into the detector input jack. Depress the 41.25 and 44.25 marker buttons and adjust the tuning so that the markers appear on the scope screen. Adjust the oscilloscope horizontal gain so that the trace is eight equal divisions long. Adjust the SWEEP WIDTH control and the TUNING CONTROL until the 41.25 marker is on the line between the fifth and sixth divisions. See figure 16 Now shift the position of the horizontal trace with the oscilloscope horizontal centering control one fourth of a division to the right. The lines on the scope screen are now exact even megahertz points of 39 through 47MHz as shown in figure 17. Any frequency in this range may now be found by using the markings on the scope screen.

Using the above method other markers may be used to calibrate the scope screen for other frequency ranges.

Occasionally a 45MHz marker is required in some alignment procedures. Although this marker is not directly available from the SM158 the 45 MHz point on a response curve can be easily and accurately determined, because it is exactly half way between the 44.25 and 45.75 markers which are available. It is not necessary to calibrate the horizontal sweep to determine the 45MHz point, just judge where the half way point is located.

TUNER ALIGNMENT

The SM158 covers the fourt important VHF channels. To check out a VHF tuner for alignment, connect the SM158 as follows:

VHF TUNER ALIGNMENT

1. Connect the RF cable terminated with the 39G22A matching pad to the VHF antenna terminals of the tuner using the Red and Green leads.
2. Apply 2 volts of bias, or the manufacturers recommended level, to the tuner AGC lint. If the tuner is a tube type, the bias is negative; If solid state, a positive voltage is generally applied.
3. If the tuner has an RF test point, connect the red lead from the 39G23 detector probe to this point. Some tuners use the IF output jack, requiring a demodulator probe. Use the Blue lead from the 39G23 at this point.
4. Connect the scope vertical input lead to the SCOPE VERT jack and the scope horizontal to the Scope Horiz jack on the SM158.
5. Set the SM158 Sweep output switch and the TV tuner to channel 10.
6. Depress the VIDEO CARRIER marker button and the SOUND CARRIER marker button. The curve should appear as shown in figure 18. The fine tuning of the TV tuner may have to be adjusted slightly to bring the response curve and markers to the right point as shown.

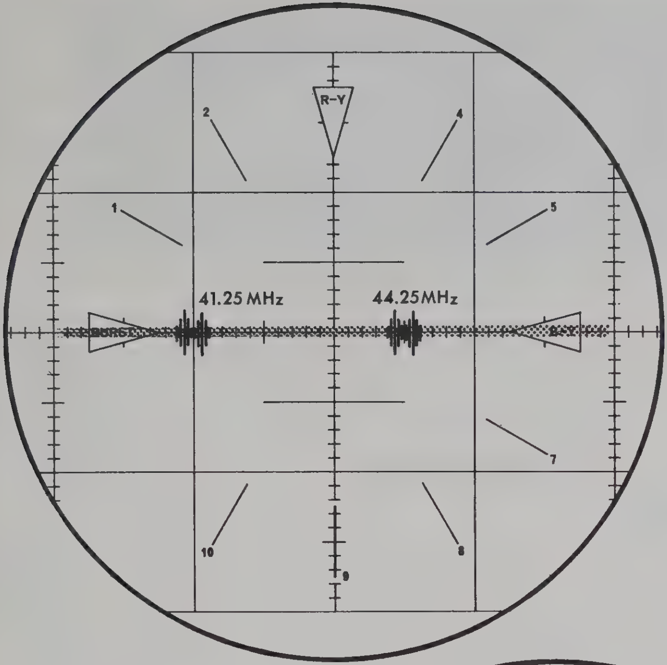
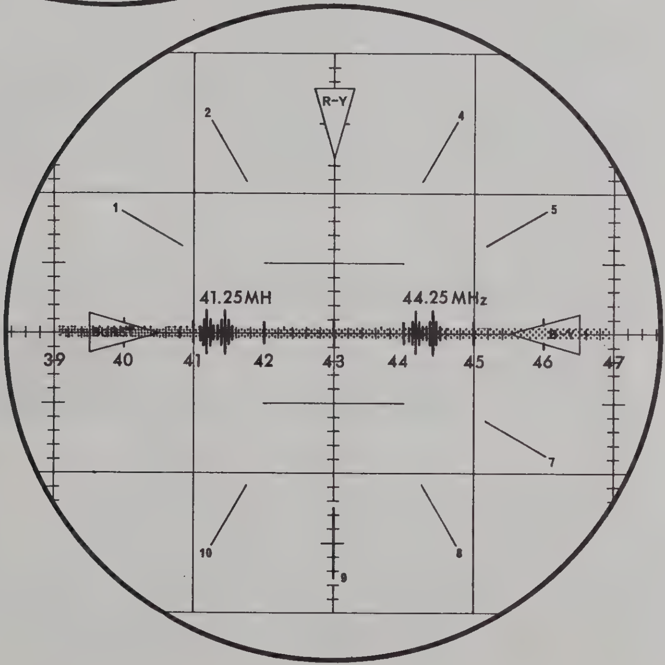

R-Y
2
4
1
5
41.25 MHz
44.25 MHz
BURST
B-Y
7
10
8
9

Fig. 16

CALIBRATION OF SCOPE SCREEN

Fig. 17

CALIBRATION OF SCOPE SCREEN IN EVEN MHz


R-Y
2
4
1
5
41.25 MH
44.25 MHz
BURST
B-Y
39
40
41
42
43
44
45
46
47
7
10
8
9

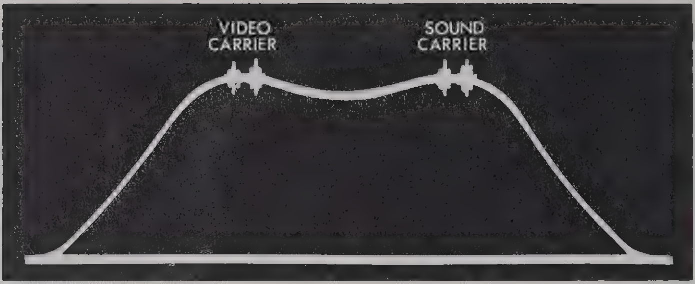


FIGURE 18 IDEAL RF RESPONSE CURVE OF TUNER

Channels 3, 4 and 13 may be checked in the same manner. If any channel required adjustment, the converter grid trimmers or RF trimmers can be touched up to give the proper display on the scope screen.

MAINTENANCE

DISASSEMBLY INSTRUCTIONS

For calabration and other internal adjustments, the SM158 must be removed from its case. To remove the SM158 Speed Aligner from its case, follow these simple steps:

1. Set the SM158 face down on the bench and remove the two screws holding the bottom of the front panel to the case.
2. Remove the two screws holding the cord wrapper to the back of the case.
3. Slowly lift the case away from the chassis and panel. This will expose all the internal parts and adjustments for calabration and maintenance.
4. If the tuner must be worked on, the tuner cover may be pulled off the tuner chassis as it is merely a force fit cover.

AMPLIFIER BOARD

The amplifier board in the tuner may be removed for service if necessary by these steps:

1. Remove the tuner cover.
2. Remove the connector to the amplifier board that are on the top of the tuner.
3. Remove the three screws holding the board to the tuner.
4. Unsolder the filter lead at the corner of the board and it is now free for removal from the tuner.

If only the dual gate MOSFET is to be replaced, the amplifier board does not have to be removed from the tuner. The MOSFET is mounted in a socket and merely removing the tuner cover exposes it for replacement.

When servicing the MOSFET, observe caution as static charges can damage it very easily. Be sure you are touching the chassis when you remove it from the socket and short the leads together with a piece of wire before letting ho of the MOSFET case.

ALIGNMENT INSTRUCTIONS

The SM158 Speed Aligner is very easy to calabrate and align if it ever becomes necessary. Follow the procedure below;

Equipment Needed:

1. Oscilloscope such as the Sencore PS148
2. RF volt meter or demodulator probe and Field Effect Meter

Preliminary set up and connections: Set the SWEEP OUTPUT switch to IF, all marker buttons out so that the markers are in the off positions, the SWEEP HEIGHT to minimum or fully counter clockwise and the MARKER HEIGHT to minimum or fully counter clockwise. Connect the SCOPE VERT jack and SCOPE HORIZ jack from the SM158 to the oscilloscope.

POWER SUPPLY

Connect a field effect meter to the plus 24 volt output on the power supply load, see figure 22. Adjust R216, the 24 volt adjust until the meter reads 24 volts. Temporarily connect a 1200 ohm 1 watt resistor from the plus 24 volt point to ground. The meter should now read 23 volts. If the meter reads higher or lower, adjust R213, the current limit adjust until the meter reads 23 volts. Disconnect the resistor.

It is important that the power supply be checked and reset of necessary before any other alignment of the Speed Aligner is preformed. A change in power supply voltage can effect both the tuning and output on the Speed Aligner.

RF OUTPUT

The minimum and maximum output from the Speed Aligner are set with R209 and R201 respectively. The best indication is with an RF voltmeter, setting R201 for about .3 volts with the SWEEP HEIGHT control to maximum and R209 for zero output with the SWEEP HEIGHT to minimum.

Using a demodulator probe such as the Sencore 39G3 and a field effect meter, a DC voltage of .5 to .55 will indicate approximately .3 volts of RF.

MARKER ALIGNMENT

Each marker can be adjusted in amplitude slightly by tuning of its associated transformer. See figure 19. Since the markers are actually crystal controlled oscillators, the frequency can not be shifted with this adjustment enough to effect alignment. If a marker is not present when the button is depressed and it will not come on when the transformer is tuned, then the oscillator circuit itself must be checked out for the trouble.

SWEEP WIDTH

To adjust the sweep width, depress the 39.75 and 47.25MHz buttons. Adjust the trace on the scope screen for 4 inches in length. With the front panel FINE TUNING control and the internal sweep width control R203, place the 47.25MHz marker on the extreme right hand side and the 39.75MHz marker in the center of the screen. By working both controls, this can easily be done. See figure 19 for location of the controls.

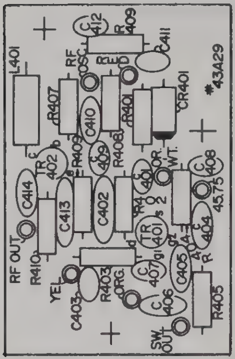

RF OUT
R410
YEL
C403
R403
ORG.
SW. OUT
C414
C413
C402
TR 402
R407
R409
C410
C409
R408
R401
RF OSC.
C412
R409
C411
CR401
L401
TR 401
C407
C406
C405
C404
R405
R404
C408
45.75
WT.
OR.
*43A29

Fig. 21 RF amplifier layout

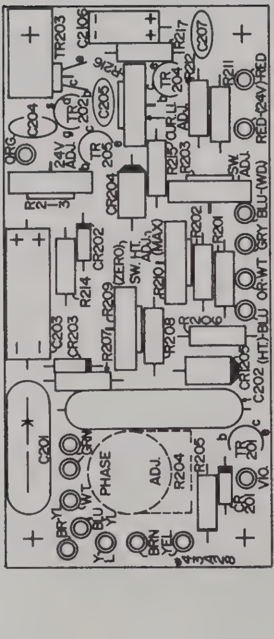

TR203
C206
C207
TR 204
R217
R212
R211
C205
C204
TR 202
TR 205
ORG.
24V ADJ.
R213
CUR.LI ADJ.
R203
SW. ADJ.
RED-(24V)-RED
R215
CR204
CR202
R214
SW. HT. ADJ.
(ZERO)
(MAX)
R209
R210
R202
R201
R207
R208
C203
CR203
CR205
C202
GRY BLU-(WD)
OR-WT
(HT.)-BLU
C201
PHASE
ADJ.
R204
R205
TR 201
CR 201
VIO
GRN
WT
BLU
YEL
BR
Y
BRN
YEL
*43A41B

Fig. 22 Power supply PC board layout

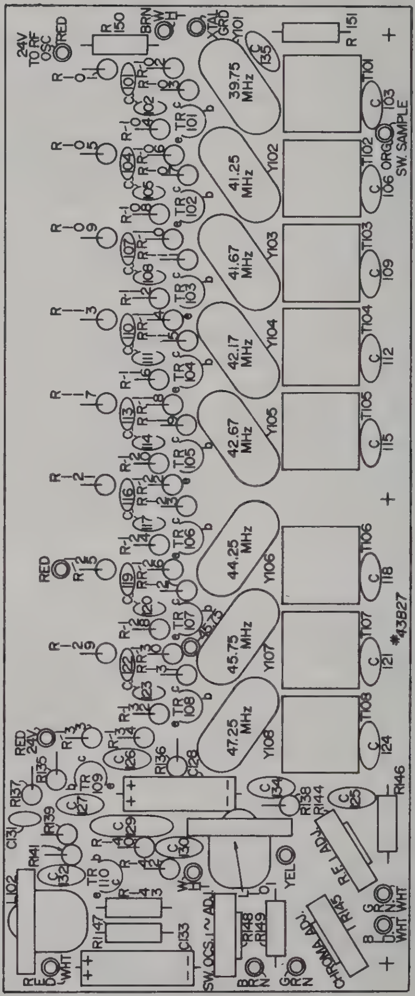

24V TO RF OSC
RED
R 150
BRN
XTAL GRD
R 151
39.75 MHz
41.25 MHz
41.67 MHz
42.17 MHz
42.67 MHz
44.25 MHz
45.75 MHz
47.25 MHz
Y101
Y102
Y103
Y104
Y105
Y106
Y107
Y108
T101
T102
T103
T104
T105
T106
T107
T108
C 103
C 106
C 109
C 112
C 115
C 118
C 121
C 124
ORG
SW. SAMPLE
TR 101
TR 102
TR 103
TR 104
TR 105
TR 106
TR 107
TR 108
TR 109
TR 110
RED
24V
R135
R136
R137
R139
R141
C131
C132
C127
C126
C128
C129
C130
C134
C125
C133
R138
R144
R146
R147
R148
R149
R145
L102
R.F. ADJ.
SW. OCS. ADJ.
CHROMA ADJ.
RED
WHT
YEL
BRN
GRN
WHT WHT
*43B27

Fig. 19 Marker PC board layout

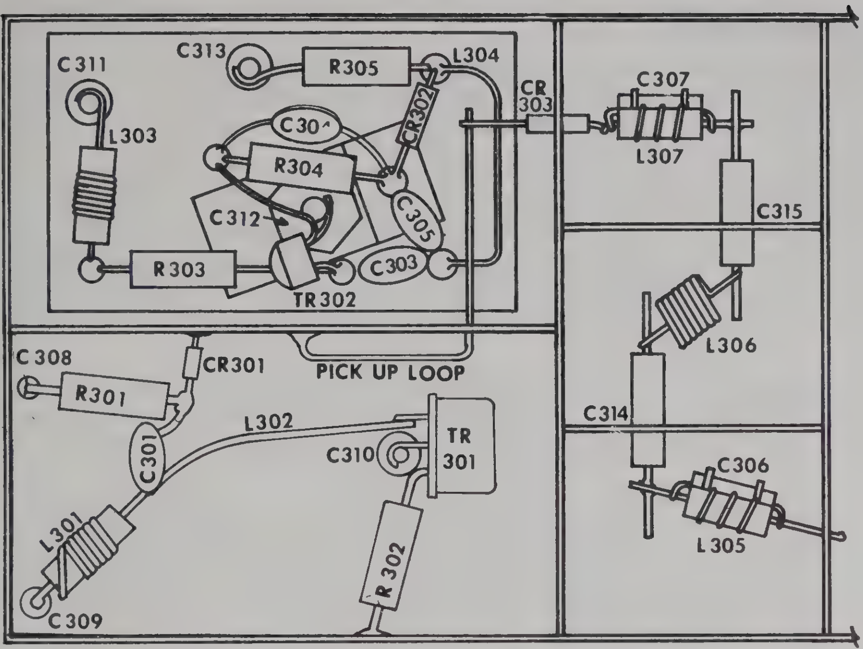

C311
C313
R305
L304
CR
303
C307
C304
CR302
L303
R304
L307
C312
C305
C315
R303
C303
TR302
L306
C308
CR301
PICK UP LOOP
R301
C314
L302
TR
301
C310
C306
C301
L301
R 302
L 305
C309

Fig. 20 UHF oscillators and filter layout

SWEEP FREQUENCY

The output frequency is controlled by 2 UHF oscillators beating together to form a fundamental output in the TV IF range. The frequency of the oscillators can be shifted with R144 RF ADJ and R148 SWEEP FREQ ADJ to re-center the output if it drifts or a componant has been changed in the UHF oscillators. For normal service, these controls will not be used. If you replace a transistor for example in the UHF oscillator, the output frequency must be reset. Depress all the marker buttons and set the front panel FINE TUNING control to its midpoint. Adjust the two controls, R144 and R148 to center the markers on the scope screen.

CHANNEL 3, 4, 10 AND 13 ADJUSTMENTS

The RF coils maybe adjusted with a field strength meter such as the Sencore FS134 or using a good working television receiver. With the field strength meter set to the proper channel, each coil is adjusted for maximum indication with the SWEEP WIDTH set to minimum.

If a T. V. receiver is used, the SM158 is connected as for an overall alignment check. Each coil is tuned on its respective channel for a response curve similar to that shown in figure 8. Be sure the T. V. fine tuning is set to the center of its range on each channel.

It is possible to tune channel 3 to 2 or 4 to 5 if you desire with the above method.

CIRCUIT DESCRIPTION

The SM158 Speed Aligner comgines Sencore experience with modern technology to make the ultimate in sweep generators that operate with ease and accuracy.

The two UHF oscillators, TR301 and TR302 form the basis of the SM158. The 44MHz basic sweep is created the difference frequencies of the two oscillators. Both are DC controlled with varicap diodes CR301 and Cr302. TR301 is the fixed oscillator, but its output frequency can be adjusted slightly with the front panel FINE TUNING control. TR302 is the swept oscillator and a 60 Hertz signal is fed into the base from TR201 blanker stage in the power supply.

The difference frequency passes through the three section low pass filter to greatly reduce the UHF frequencies passed into the RF amplifier stage. The output of the filter is also coupled into the marker buss line on the marker board.

The RF amplifier, TR401 is a dual gate MOSFET. The difference signal of 44MHz swept is applied to the first gate and a DC voltage to the second gate. The D.C. voltage is used to control the gain of the amplifier and therefore the output RF signal from the SM158.

TR402 Acts as an amplifier, and impedance match to the RF output jack and as a mixer for the 4 VHF RF signals. In IF, TR402 acts as an amplifier and matching stage. When the switch is on channel 3, 4, 10, or 13, it mixes the 44MHz swept signal with the RF signal from TR1. TR1's output frequency is combined with the 44MHz swept signal to produce an RF swept signal on the desired channel for overall alignment checks and tuner alignment.

The markers are generated by mixing the output of the crystal controlled marker oscillators with the sample of 44MHz swept signal. The two signals are combined and the audio beat detected in TR109. TR109 and TR110 act as an amplifier, increasing the amplitude of the signal and coupling it to either the SCOPE VERT jack or SCOPE HORIZ jack depending upon the position of S2. S2 is a push pull switch mounted on the back of R1, the marker amplitude control.

The power supply is a 24 volt regulated and current limiting supply. TR203 is a standard pass transistor and TR205 an error amplifier. The base of TR205 is set up to provide 24 volts at the output. If the current drain exceeds 100mA, then the current limiter, TR204 decreases the bias on TR205, reducing the output voltage, thereby reducing the current from the supply. This protects the power supply and componants if a short should occur in the 24 volt line in the generator. A .2 amp fuse in the primary of the power supply protects the power transofrmer in the SM158.

TROUBLE	CAUSE AND ACTION
No Response curve but all markers visable	Check TR401 and TR402, in tuner for defective transistor. Check CR401 diode for open or short. Check connections to tuner for open.
No Response Curve or markers visable	Check 24 volt power supply for low or absent output. Check TR301 and TR302 in tuner, may be defective. Check CR303 for open & shorted condition.
Response curve but no markers	Check sweep sample connections from tuner. Check birdie amp. TR109 or TR110 may be defective.
No RF response curve, but good IF curve	Check S3 for defective contacts TR1 may be defective.
Some markers missing	Check tuning of transformer and transistor for defect. Check switch contacts for dirt. Use good tuner cleaner on switch contacts.
Response curve on IF but not on chroma	Check 45.75 MHz input to tuner. Check diode in 39G23 detector probe for open or short.
Unit completely dead	Check .2 amp fuse on rear of SM158.

SERVICE AND WARRANTY

You have just purchased one of the finest sweep marker generators on the market today. The SM158 has been inspected and tested twice at the factory in insure the best quality instrument to you. If something should happen, the SM158 is covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument.

For the best service on out of warranty work, send the SM158 directly to the factory service department. Be sure to pack the instrument well and insure it in case it is damaged in shipment. Do not ship the unit back in the display carton alone. An outer carton should also be used and a resilient packing material used around the SM158 to prevent any possibility of damage.

To speed up the service on your SM158, be sure to include a note stating the nature of your problem, such as "No RF output on channel 10". If you are returning the unit for calibration only, please state this. Complete information will insure faster service.

If you wish to repair your own SM158, we have included a schematic, parts list and trouble chart. Any of these parts may be ordered directly from the factory service department.

We reserve the right to examine defective components before in warranty replacement part is issued.

SENCORE
NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT
3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

Form 560
Printed in U. S. A.

SERVICE AND WARRANTY

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SENCORE
NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT
3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

Form 560

Printed in U. S. A.

SM
158
SPEED ALIGNER
SWEEP AND MARKE
GENERATOR

SENCORE

MANUAL

SENCORE SERVICE
3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

Safety Precautions

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. An isolation transformer should always be used on equipment having the chassis tied to one side of the AC power line.

2. When making test lead connections to high voltage points, remove the power. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.

3. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.

4. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.

5. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.

6. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, such as falling against the equipment, or coming in contact with high voltages.

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INSTRUCTION MANUAL FOR THE SENCORE
SM158 SPEED ALIGNER SWEEP AND MARKER GENERATOR

DESCRIPTION

Faster and more accurate alignment equipment has been demanded by the electronic maintenance field. Sencore engineers have met this demand in the SM158 Speed Aligner. The Speed Aligner gives the required IF and chroma sweep signals and four RF channels for tuner checking with up to 44 different crystal controlled markers. These features along with the simplicity of operation makes the SM158 Speed Aligner ideal for the service industry. Compare these features and see why the SM158 is truly a unique sweep generator.

*Flat output generates text book response curves.
*Full 15MHz sweep width.
*All prefixed frequencies for faster and easier alignment.
*Up to 44 different crystal controlled markers for chroma, IF and RF channels.
*Horizontal or Vertical markers.
*Small, compact and easy to use.

SPECIFICATIONS

RF Output: Variable 10uV to over 100mV, flatness ±1.5db
Frequency Coverage: IF, and RF channels 3, 4, 10 and 13
Chroma: 45.75 MHz picture carrier with 42.17 MHz swept subcarrier
Sweep: Variable, 0.3-15MHz; linearity 1.5% sweep rate 60Hz
Markers (Post Injection System used):
TV IF crystal controlled markers:
39.75, 41.25, 41.67, 42.17, 42.67, 44.25, 45.75, 47.25 MHz
Chroma crystal controlled markers:
3.08, 3.58, 4.08 MHz
Sound IF crystal controlled marker:
4.5 MHz
TV RF Markers: Adj. sound trap, IF carrier, color carrier and sidebands, sound carrier, and adj. video trap
SIZE: 7"HX 10 3/4"LX6"D
WEIGHT: 9 Lbs.

SEMICONDUCTOR COMPLEMENT

17 Bi Polar transistors
1 Junction FET
1 Dual Gate MOSFET
3 Diodes
3 Zener Diodes
2 Varicap diodes

OPERATION

CONTROLS ON THE SM158 SPEED ALIGNER

SWEEP OUTPUT SWITCH: Selects one of the Six different frequencies used for alignment of the TV receiver.

FINE TUNING CONTROL: Allows the response curve to be shifted several megahertz either side of center for faster trap alignment.

SWEEP HEIGHT CONTROL: Controls the RF output level from the SM158 Speed Aligner.

SWEEP WIDTH CONTROL: Varies the sweep width from about .1MHz to 15 MHz.

RF OUTPUT JACK: All sweep signals from the SM158 appear at this jack.

CRYSTAL CONTROLLED MARKERS PUSH BUTTONS: Used to select one or more of the total 44 different marker frequencies used in IF, RF, and Chroma alignment.

MARKER HEIGHT: A variable control so that the desired height of marker can be placed on the screen according to the users wishes. The push-pull switch on the MARKER HEIGHT control allows the selection of either vertical or horizontal markers to be displayed on the response curve.

DETECTOR IN JACK: The signal from the TV receiver is put into the jack with the 39G23 detector probe.

SCOPE VERT. JACK: Provides the response curve and vertical markers for the vertical input to the scope.

SCOPE HORIZ. JACK: Provides a 60 Hertz horizontal sweep for scopes not having an internal line position and markers for the horizontal marker position of the MARKER HEIGHT Control. No horizontal markers will appear unless this jack is used.

OFF-ON SWITCH: Controls the AC power to the unit and glows in the on position acting as a pilot light.

PHASE ADJUST: Adjusts the phase of the horizontal signal to the scope to compensate for phase errors in the scope, and is located on the rear of the Speed Aligner.

39G22A MATCHING PAD

The 39G22 matching pad that comes with the Speed Aligner is used to match into the mixer test points for IF and chroma; the 300 ohm input of the tuner for RF alignment; and is used to terminate the RF cable to eliminate standing waves and distortion of the response curve. If the matching pad is not used, serious standing waves can result causing the response curve to be

tilted and the results will be questionable. If a 75 ohm input such as a distribution system or cable system is to be checked, the 75 ohm output cable can be used directly without the matching pad. When connecting the 300 ohm antenna input use the red and green leads. When connecting to the mixer test point or other low impedance point, use the black lead to ground and the red lead to the test point or ungrounded tube shield.

39G23 VIDEO DETECTOR PROBE

The special video detector probe No. 39G23 has a build in isolation resistor and a video detector, making the SM158 complete for all alignment procedures. The Red lead of the 39G23 has a 27,000 ohm resistor between the Red lead and the input of the SM158 for isolation. The Red lead is connected to the video detector output, or the mixer grid test point on a TV tuner to couple the response curve to the marker adder section of the SM158. The isolation resistor prevents loading the test circuit.

The blue lead of the 39G23 is the input to the video detector. This lead is used when a demodulator probe is required in the alignment procedure such as at the output of the chroma bandpass amplifier for chroma alignment or the output of the tuner for tuner alignment.

OPERATING THE SM158

The operation of the Speed Aligner has been made so simple and easy that it can almost be operated by the average technician without the aid of instructions. The controls have been made self explanitory so that a minimum amount of time is required to get the maximum benefit from the Speed aligner.

Lets look at each control and see how it is used to obtain a response curve from the television receiver.

SWEEP OUTPUT Switch: selects the desired sweeped RF output, IF at 44 MHz, RF at channels 3, 4, 10 and 13 or the special Chroma signal for injection through the IF stages for chroma bandpass alignment. Each signal is fixed so that no hunting around is required, simply flip the switch and get the desired swept frequency.

FINE TUNING Control: Allows the sweep center frequency to be shifted several megahertz each direction. This is to facilitate trap alignment and for checking the skirts on the tuner and IF response curves for trouble shooting.

SWEEP WIDTH Control: is used to vary the width of the swept signal from a few hundred Kilohertz to a full 15 megaherts for full alignment.

SWEEP HEIGHT Control: controls the swept RF output signal level from only a few microvolts to over 250 millivolts or 1/4 of a volt. This level is usefull for forcing signal through a defective receiver or one that has been "touched up" and is way out of alignment.

CRYSTAL CONTROLLED MARKER ADDER Push Buttons: are used to select one or more of the 44 different crystal controlled markers available from the SM158 Speed Aligner. When the SWEEP OUTPUT switch is in the IF position, the marker frequencies indicated in the IF column are available. When the SWEEP OUTPUT switch is in the CHROMA Position, the markers are 4.5, 4.08, 3.58, and 3.08 MHz as required for Chroma alignment.

When the SWEEP OUTPUT switch is set to any one of the four RF channels, the markers automatically become the Adjacent Video trap; sound Carrier, Color Carrier, Video Carrier and Adjacent Sound trap markers; just press the desired button and the correct marker automatically appears.

MARKER HEIGHT Control; serves a dual purpose of controlling not only the height of the markers as seen on the response curve, but has a push pull switch which allows the selection of either regular vertical markers or horizontal markers.

RF OUTPUT TO TV; contains all the swept RF signals for injection through the RF cable to the television receiver.

DETECTOR IN TO TV: jack is where the detected signal from the video detector or output of the chroma bandpass amplifier is fed with the 39G23 detector cable so that the markers may be added to the response curve.

TO SCOPE VERT jack: contains the IF response curve and the marker signals when the MARKER HEIGHT control is pushed in.

TO SCOPE HORIZ jack: has the horizontal sweep signal and also contains the marker signal when the MARKER HEIGHT control is pulled out. If this jack is not used and the regular line sweep of the scope is used to display the response curve, then the horizontal markers will not be visable on the scope \screen.

APPLICATIONS

WHAT IS SWEEP ALIGNMENT

A tuned amplifier, such as the IF amplifier in a television receiver, is designed to pass a band of frequencies and reject the frequencies outside of this band. For example a color television IF amplifier is designed to pass frequencies between 41.67 and 46.75 MHz and reject frequencies below 41.25 and above 47.25 MHz. This wide pass band is obtained by having several IF stages each tuned to a different part of the band, i.e.; stagger tuned. Alignment of this amplifier with a standard signal generator is difficult, because each stage has to be aligned individually and then the overall response checked by laboriously recording the output as input frequency is changed in small steps across the band. Plotting output against frequency on a graph would then show the response of the amplifier.

If you were able to tune the frequency of the signal generator at an even rate back and forth across the frequency band of interest you could observe the output (after detection) on an oscilloscope and actually see the response of the amplifier. This is what is done in a sweep generator. The output signal from the generator is a constantly changing frequency over a selected range as determined by tuning and the sweep width settings of the generator. The rate at which the output is swept is low, generally for convenience, the frequency of the AC line.

Markers are added to the response curve to accurately show the frequency at different parts of the curve. They are generated by amplifying the low frequencies on each side of the zero beat that develops when the frequency of the sweep signal passes through the marker oscillator frequency. Generating markers external to the amplifier under test and adding them to the response curve is called post injection. It is superior to a preinjection system where the marker oscillator signal is fed to the amplifier under test along with the sweep signal. Markers developed this way can distort the response curve or are lost in traps making sweep alignment more difficult.

THE COLOR TV IF RESPONSE CURVE

The ideal color TV IF response curve is shown in figure 1. You should become totally familiar with this curve, because it can be an excellent trouble shooting aid. Note that the top of the curve shown is flat. However, some set may have a dip in the top; and others may (newer color sets) have a rounded or "hay stack" top.

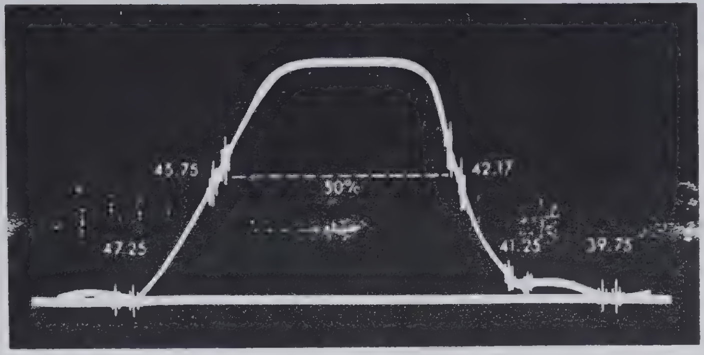


Fig. 1. Ideal Response curve

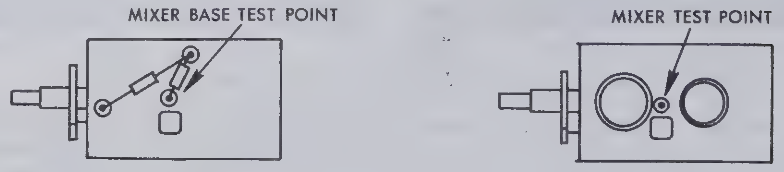
The shape of the response curve skirts is very important. The picture carrier (45.75MHz) and the color sub carrier (42.17MHz) are approximately at the 50 percent points on the skirts. Color signal information 0.5MHz away (41.67) MHz must still pass through the amplifier, but the sound carrier (41.25MHz) must be trapped out so this skirt has a fairly steep slope. The opposite slope is not quite as steep, but should rise linearily for best recovery of low frequency video information. The upper adjacent channel picture carrier (39.75 MHz) and the lower adjacent channel sound carrier (47.25MHz) must be trapped out to prevent interference. The amplifier has minimum or zero gain at these frequencies.

There are a number of things that will affect the response curve. If a trap is misadjusted for example, it will be impossible to get the correct curve and a lot of time can be wasted if this is not recognized. One or more weak stages will also give a poor curve so the tubes should always be checked or substituted before alignment is attempted. The design of an amplifier takes into account the internal tube capacity. When tubes are replaced in an amplifier a different internal capacity could upset the alignment. Study the curve in Figure 1. When you know how the curve should look you will be able to pin-point troubles fast. If tubes are replaced, the set should be "aged" for several hours before realignment is attempted. This will allow the tubes to stabilize.

CONNECTING THE SM158 FOR ALIGNMENT

The SM158 is extremely easy to connect and will require only three cables for the total alignment of a color television receiver, or four if you wish to have horizontal or vertical markers. How to connect these cables is covered in the section below:

RF CABLE: The RF cable is connected to the antenna terminals, the mixer test point in the tuner, or to the individual IF stages depending on the alignment instructions of the particular manufacturer. The 39G22A matching pad is used in most cases as it not only acts as a 300 ohm match for the antenna terminals found on the TV set, but terminates the cable so that no standing waves are present. When using the RF frequencies of channel 3 and above, the RF cable is connected to the antenna terminals of the set using the red and green leads. If TV IF alignment is being performed, the RF cable with the 39G22A matching pad connected is either connected to the mixer test point or capacity coupled to the mixer tubes with the red lead, and the black lead to ground. The test point is easy to find as it is generally located next to a square hole in the tuner. Figure 2 shows this location on a tube and transistor tuner. On some solid state tuners, the test point is on top of the tuner as in the tube model, and in others it maybe located on the side of the tuner.



TYPICAL TRANSISTOR TUNER
TEST POINT LOCATION

TYPICAL TUBE TYPE TUNER
TEST POINT LOCATION

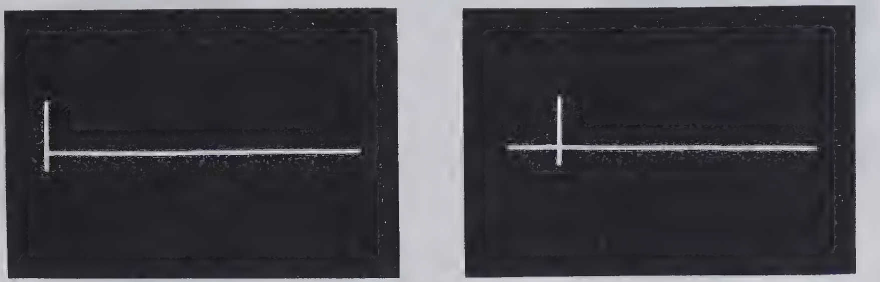
FIGURE 2 .

To capacity couple to the mixer tube, you can use an ungrounded tube shield or use a conductive foil wrapped around the mixer tube when the shield is not removable. The foil should be covered with tape to prevent it shorting to the shield. In either case the red lead of the 39G22A matching pad is connected to the shield or foil and the black lead to ground. When injecting the signal into individual IF stages, a .001 disc capacitor should be placed in series with the red lead of the 39G22A. The 39G22A matching pad is not used when matching into 75 ohm systems.

The DETECTOR CABLE is connected from the SM158 DETECTOR IN jack to the various points as described in the individual alignment procedures that follow.

The SCOPE Vertical input cable is connected from the SCOPE VERT jack on the SM158 to the vertical input of the scope.

The SCOPE HORIZ jack is connected to the horizontal input of the scope and the scope selecter switch set to EXTERNAL.



Correct Phase Adjustment Incorrect Phase Adjustment

FIGURE 3

PHASE ADJUSTMENT

The PHASE ADJ found on the rear of the Speed Aligner is normally set once for the scope you use and then not touched again unless the scope is changed. The phase adjustment can be checked very easily by observing the trace on the scope without any signal input to the DETECTOR IN jack. Figure 3 shows the in-phase condition and the out of phase condition. Note the spike on the curve should appear at the extreme end of the horizontal base line for proper phase adjustment. If not, then the scope and Speed Aligner are out of phase and distortion of the response curve can result.

DETERMINING THE ACCURACY OF THE SCOPE FOR SWEEP ALIGNMENT

The oscilloscope is an important tool in sweep alignment. If the scope does not have a good low frequency response, has a phase shift in the vertical amplifier, or a phase shift between the horizontal and vertical amplifier, the response curve on the scope screen can be misleading as to the actual condition of the television receiver. Any of the above conditions can distort the response curve enough to give inaccurate results when the TV set is aligned. The Sencore SM158 has an ultra linear sweep and a flat output that can be used to check out the scope before any alignment is started. If the scope is checked out, the results can be taken into consideration when doing the alignment for a more precise job.

To make the accuracy check with the SM158 on your scope, follow these steps:

1. Set the SM158 to IF and maximum RF output.

2. Connect the RF cable using the red lead of the matching pad to the detector probe blue lead, black lead to black lead, and the scope vertical input to the SCOPE VERT jack on the SM158.

3. Adjust the scope vertical gain until a usable pattern is seen. If the scope is good and has no phase shift and has a good low frequency response, the pattern should appear as shown in figure 4

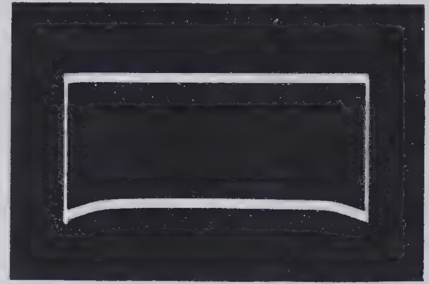


Fig. 4 Flat scope response

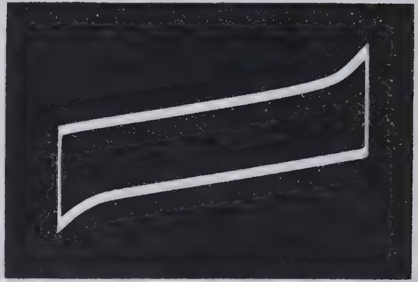


Fig. 5 Poor vertical low frequency response

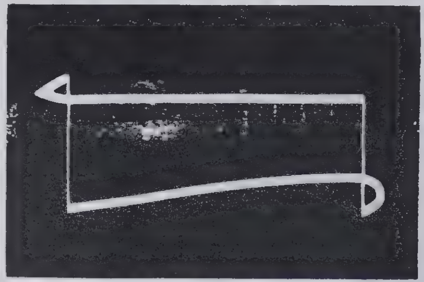


Fig. 6 Phase shift in the horizontal amplifier

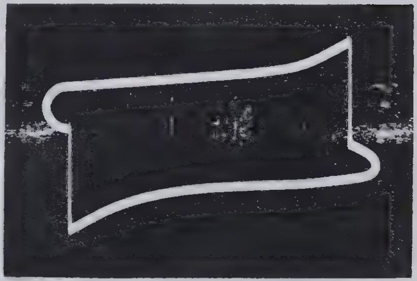


Fig. 7 Phase shift and poor low frequency response

If the scope has a poor low frequency response, the pattern will appear as shown in figure 5. The more the pattern bows or tilts the worse the low frequency response is. Some bowing or tilting of the pattern will be acceptable and should be taken into consideration when adjusting the television receiver. Figures 6 and 7 show other various scope troubles. If any of these problems appear to excess, it will affect the response curve of the TV set.

OVERALL ALIGNMENT CHECK WITH THE SM158

An overall alignment check should be made when the alignment of the television receiver is in question, or as a general procedure to insure your customer the best possible picture. The overall procedure outlined below will check the tuner and IF amplifiers from the antenna terminals to the video detector. If there is any misalignment or other troubles, they will show up on this check. Connect as shown in figure 8.

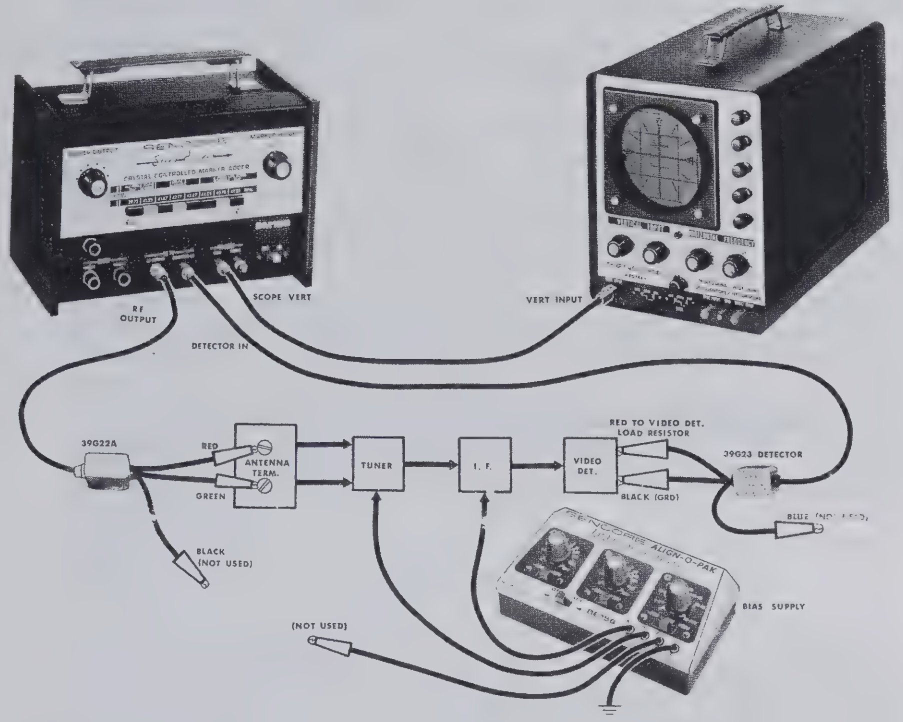


Fig. 8 Connecting for overall alignment check

To make the overall alignment check with the SM158 proceed as follows:

1. Connect the RF cable terminated with the 39G22A matching pad from the SM158 RF OUT jack to the antenna terminals of the television receiver.
2. Set the SM158 Range switch to channel 10. Set the TV tuner to Channel 10 also.
3. Connect the 39G23 detector probe Red lead to the video detector load resistor or the grid of the first video amplifier. In many TV receivers, there is a terminal at the top of the chassis for the detector and AGC test point. The other end of the detector cable should be connected to the DETECTOR IN jack on the front panel of the SM158.
4. Apply a bias to the IF and tuner AGC test points. Some manufacturers recommend shorting the IF AGC ground. Be sure to check the manufacturers literature. A negative two volt bias is used on the tuner in tube receivers. Solid state receivers use positive or negative bias depending on the type of transistor used and if forward or reverse AGC is used.
5. Connect the scope vertical input to the SCOPE VERT jack on the front panel and the scope horizontal input to the SCOPE HORIZ jack on the front panel. The scope vertical sensitivity should be set so that a two volt peak to peak signal will give two inches of vertical deflection. A two volt signal from the video detector is a good average output to maintain during the alignment.
6. Set the RF OUTPUT control until you have a 2" response curve.
7. Depress the Video carrier marker button and adjust the fine tuning control of the television receiver until the marker rests on the 50% point of the response curve as shown in figure 9. Depress the color carrier marker button. The marker should fall at the 50% point on the opposite end of the curve as shown in figure 9.

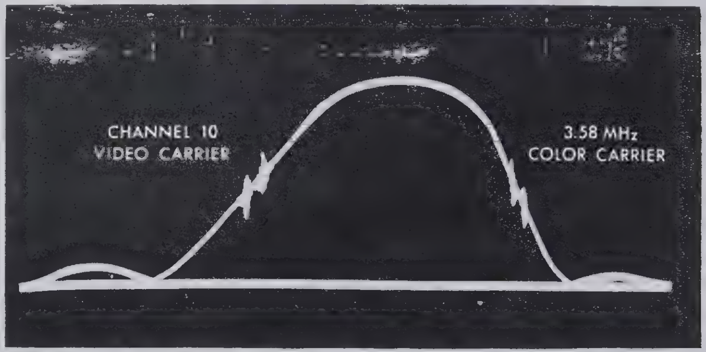


Fig. 9 Overall response curve

If the overall response curve is not as shown in figure 9, then the television receiver is in need of alignment. The stages that are most likely to be off are the IF amplifiers. If the overall alignment is off, proceed with the IF alignment check.

IF RESPONSE CURVE CHECK

The IF amplifiers of the television receiver are the most critical amplifiers in the set. Most of the variations of the overall response curve will be the result of changes in the IF amplifiers. Tube capacity differs from tube to tube and transistor to transistor, so that when a new tube or transistor is replaced in the IF, the response curve will change. To make a quick check of the IF response, follow these simple steps:

1. Connect the 39G22A matching pad red lead to the mixer test point or capacity couple into the mixer tube as described in "CONNECTING THE SM158 FOR ALIGNMENT". Connect the Black lead to ground.
2. Connect the red lead of the 39G23 detector probe to the video detector load resistor or input of the first video amplifier. Connect the black lead to ground.
3. Connect the scope vertical input to the SCOPE VERT jack on the front panel of the SM158 and the scope Horiz input to the SCOPE Horiz jack.
4. Connect a bias supply to the IF AGC test point. If you do not have a schematic, follow the grid load resistor and connect the negative lead of the supply to the end of this resistor. If the IF is solid state, find the base resistor and connect a negative bias supply to the end opposite the base end. In tube receivers, a negative 2 to 3 volts is normally used, and in solid state receivers a positive voltage will be normal. The amount of voltage should be taken from the service literature.
5. Set the VHF tuner to a high channel such as 13.
6. Set the SM158 Range switch to IF, and the SWEEP WIDTH control until all 8 markers are visible on the scope screen.
7. Adjust the SWEEP HEIGHT control until you have a 2 volt peak to peak response curve.
8. Depress the 45.75 and the 42.17 markers and adjust the MARKER HEIGHT control until the markers are to your liking.

The response curve should appear as shown in figure 9. Note that the curve may be a flat topped curve and that some of the later model sets will have a "Haystack" or rounded top curve. In both cases, the video and color carriers should fall at about the 50% points on the curve for the best alignment. You can depress the trap and color sideband limit markers at this time so that all eight markers a visable on the curve. The traps should be on the baseline indicating minimum gain and the color sideband limits should falls as shown in figure 10.

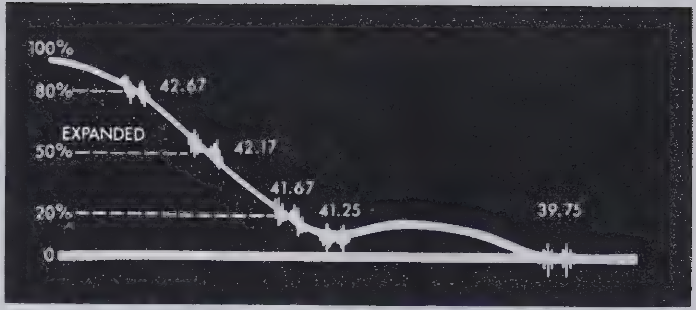


Fig. 10 Color slope of response curve

EASY TRAP ADJUSTMENT

You can increase the gain of the vertical scope amplifier and reduce the sweep width to about that shown in figure 10. This will allow you to observe the action on the trap coil as you adjust it. Simply place the marker in the dip for minimum gain at the trap frequency. This is the fastest and most accurate method of trap alignment in the color receiver.

Each manufacture has a different method of alignment for his particular television receiver. It is best to follow these alignment instructions for the proper test points and order of alignment. Above all, be sure the traps are properly set before alignment of any of the IF transformers are under taken. This will insure you getting the proper alignment curve in the shortest time.

INTERFERENCE ON THE RESPONSE CURVE

Hash and interference on the response curve can be caused by both the horizontal output circuit and the vertical output circuit radiating. The horizontal output tube will cause a hash or grass on the overall curve as shown in figure 11 while the vertical circuit will cause a spike to drift through the response curve and cause distortion. The following describes how each type of interference can be eliminated.

Horizontal Output Tube Radiation: One of the easiest ways to remove the horizontal output radiation is to remove the horizontal output tube from its socket. Do NOT merely take the cap off, because in some circuits, the screen of the output tube will be destroyed. In a series string type receiver, it is very difficult to take the tube out without disrupting the entire set, unless a dummy tube or resistor is put in its place. A very handy and easy way is to use the Sencore RC146, Handy 75, power resistor section of 20 values at 20 watts and connect the output of this section across the filament pins of the tube socket. If it is compactron, the filament pins are 1 and 12 and if it is a novar, pins 4 and 5. There may be a tube or two with variations of this, but these are the most common filament pins. Consult a tube manual or the set schematic if in doubt. With the Handy 75 connected to

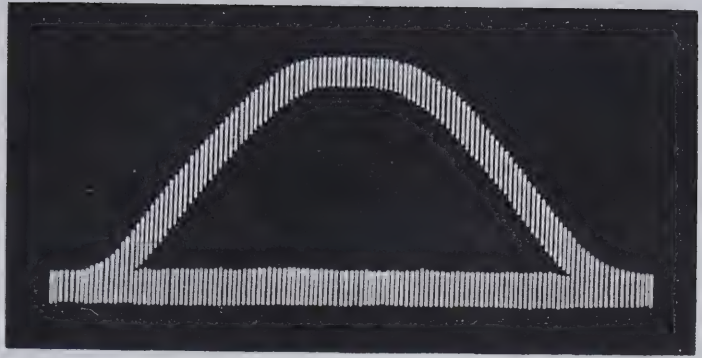


FIGURE 11   HORIZONTAL INTERFERENCE CAUSE BY OUTPUT TUBE

the filament pins, connect a volt meter across the filament pins and adjust the selector switch with the TV set on to provide a voltage drop equal to the filament voltage of the tube that was removed.

Vertical Circuit Interference: Interference from the vertical circuits is generally a spike that will drift through the response curve and cause distortion as it passes through. This is created because of the slight difference in frequency between the vertical frequency of the set and that of the sweep generator. In many cases, the vertical hold control can be adjusted to lock the spike in at the end of the response curve where it is out of the way. Some sets have a "set up" switch. This switch can be used to disable the vertical deflection system, eliminating the vertical interference.

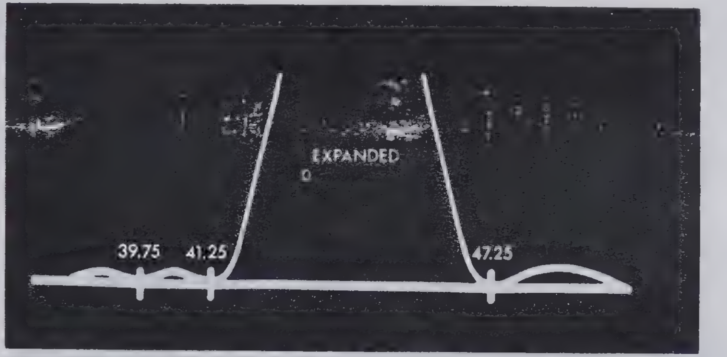

EXPANDED
39.75
41.25
47.25

FIGURE 12 LOCATION OF TRAPS ON RESPONSE CURVE

A good point to remember is to use the video and color carrier markers when making the touch up adjustments. If you do this, you will be sure that you are not shifting the carrier points above or below their respective 50 percent points on the curve.

CHROMA BANDPASS ALIGNMENT

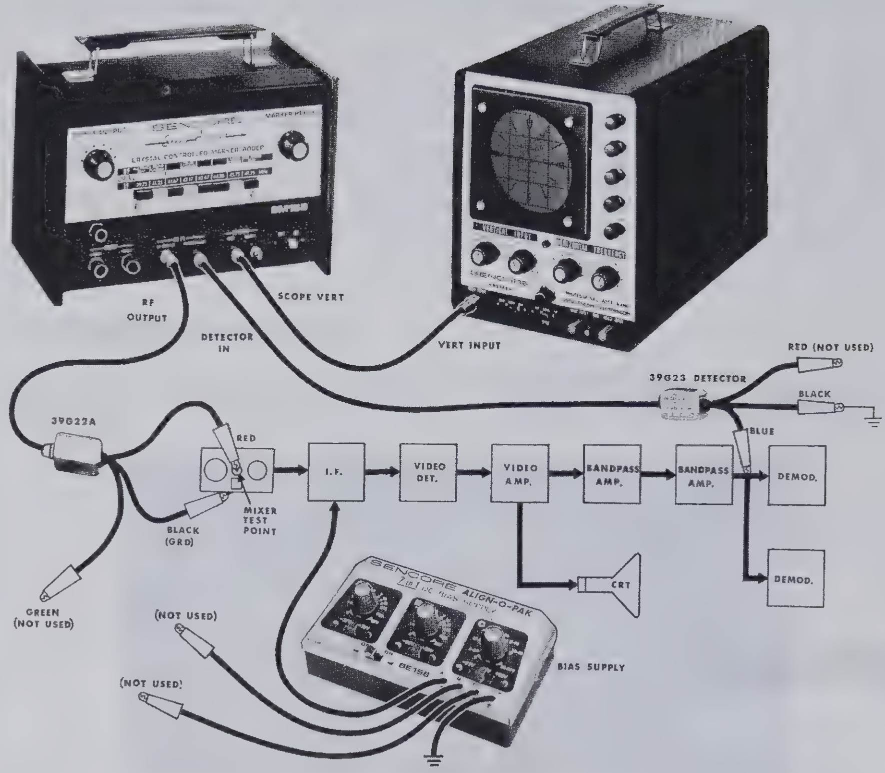

RF OUTPUT
DETECTOR IN
SCOPE VERT
VERT INPUT
RED (NOT USED)
39G23 DETECTOR
BLACK
BLUE
39G22A
RED
I.F.
VIDEO DET.
VIDEO AMP.
BANDPASS AMP.
BANDPASS AMP.
DEMOD.
DEMOD.
MIXER TEST POINT
BLACK (GRD)
GREEN (NOT USED)
(NOT USED)
(NOT USED)
CRT
BIAS SUPPLY
SENCORE ALIGN-O-PAK
BE158

FIGURE 13

CONNECTING FOR BANDPASS ALIGNMENT THROUGH THE VIDEO IF

Color signal information is amplified unequally as it passes through the IF amplifier, because the color subcarrier is at the 50 percent point on the response curve skirt. The bandpass amplifier must make up for this condition by amplifying the color signal information unequally in the opposite direction, so that the net effect is equal amplification of the entire color signal. The only way that the bandpass amplifier can be aligned easily is to feed a special signal through the IF and observe the bandpass response at the output of the bandpass amplifier. See Figure 13. The SM158 provides this necessary signal when the SWEEP OUTPUT switch is set to CHROMA.

NOTE: It is very important that the IF response is aligned first, because good alignment of the bandpass amplifier depends on proper IF alignment.

After the IF has been aligned or checked, simply turn the SWEEP OUTPUT switch to the CHROMA position and connect the Blue lead of the 39G23 detector probe to the output of the bandpass amplifier and you are set to check out and align the chroma section of the receiver. Follow these simple steps:

1. Connect the 39G22 matching pad to the tuner testpoint (see figure 2) or capacity couple to the mixer tube as described in CONNECTING THE SM158 FOR ALIGNMENT.
2. Connect the Blue lead of the 39G23 detector probe to the output of the bandpass amplifier, or to the cathode of one of the demodulators, and the Black lead to ground.
3. Connect a bias supply to the IF AGC test point. A positive voltage is needed if the set is solid state and negative voltage for a tube set. In some cases, the manufacturer will tell you to ground out the AGC test point in a tube receiver. This also will hold true for the chroma alignment.
4. Set the TV receiver to a high channel such as 13.
5. Set the Sweep Height control on the SM158 as you would for IF alignment. A two volt peak to peak response curve is normal with most sets.
6. The scope vertical input should now be connected to the SCOPE VERT jack on the SM158 and the scope horizontal input to the SCOPE HORIZ jack.

The best procedure for alignment of the chroma is to follow the manufacturer's service procedure. The overall curve should appear as shown in figure 14.

Note that the 3.08 and 4.08 markers should be equally spaced and appear near the 80% points on the curve. In many sets, an automative 3.58 marker may appear on the curve due to the 3.58 crystal in the set.

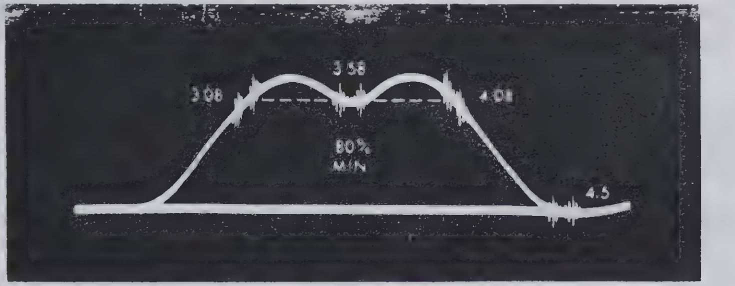


FIG. 14 CHROMA BANDPASS CURVE THROUGH IF

In most cases, the chroma take off coil is peaked at 3.58MHz for maximum gain while the second and third transformers will affect the 3.08 and 4.08 marker positions on the curve respectively. This will not always hold true, so check the manufacturers literature for their recommended procedure.

SPECIAL NOTE: when doing chroma alignment depress only the 4.5, 4.08, 3.58, and 3.08MHz marker buttons. The other markers may cause a slight beat effect on the response curve. This in no way effects the curve, but may become annoying to the technician. The 3.58MHz marker may also beat with the internal crystal in the television receiver. This can be eliminated by turning the 3.58MHz marker button off. The crystal in the television receiver will produce a 3.58 marker automatically on the response curve.

AFT ALIGNMENT (automatic fine tuning)

With many of the newer color sets having automatic fine tuning circuits, alignment will be necessary as the circuit ages and drifts or a componant is changed.

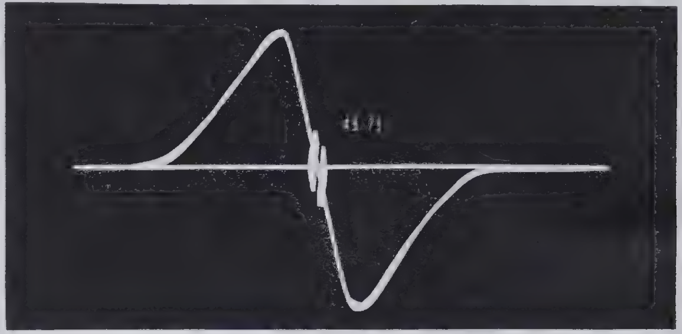


Fig. 15 AFT "S" Curve

The connections for AFT alignment are identical to those of IF alignment except the 39G23 detector probe is connected to the output of the AFT circuit and not the video detector. It is best to follow the manufacturers alignment procedure here for best results. Basicly, the resultant curve is an "S" curve. The 45.75MHz video carrier must be positioned on the cross over point with equal symmetry above and below for best pull in. The peaks of the "S" curve will be about 1 to 1.5MHz above and below the 45.75MHz video carrier. See figure 15 for typical AFT "S" curve.

FINDING MARKER POINTS OTHER THAN THOSE PROVIDED

The Sencore SM158 has eight crystal controlled markers available to cover all the major points on the response curve. There are times however, that markers other than those provided may be desired for various reasons. The SM158 sweep is so linear that the different marker points can be approximated

on the scope screen with ease. For most alignment work, this method is fast and easy. If greater accuracy is desired, the following method can be used to calibrate the horizontal trace for exact frequency points.

Connect the SM158 to the oscilloscope without any signal going into the detector input jack. Depress the 41.25 and 44.25 marker buttons and adjust the tuning so that the markers appear on the scope screen. Adjust the oscilloscope horizontal gain so that the trace is eight equal divisions long. Adjust the SWEEP WIDTH control and the TUNING CONTROL until the 41.25 marker is on the line between the fifth and sixth divisions. See figure 16 Now shift the position of the horizontal trace with the oscilloscope horizontal centering control one fourth of a division to the right. The lines on the scope screen are now exact even megahertz points of 39 through 47MHz as shown in figure 17. Any frequency in this range may now be found by using the markings on the scope screen.

Using the above method other markers may be used to calibrate the scope screen for other frequency ranges.

Occasionally a 45MHz marker is required in some alignment procedures. Although this marker is not directly available from the SM158 the 45 MHz point on a response curve can be easily and accurately determined, because it is exactly half way between the 44.25 and 45.75 markers which are available. It is not necessary to calibrate the horizontal sweep to determine the 45MHz point, just judge where the half way point is located.

TUNER ALIGNMENT

The SM158 covers the fourt important VHF channels. To check out a VHF tuner for alignment, connect the SM158 as follows:

VHF TUNER ALIGNMENT

1. Connect the RF cable terminated with the 39G22A matching pad to the VHF antenna terminals of the tuner using the Red and Green leads.
2. Apply 2 volts of bias, or the manufacturers recommended level, to the tuner AGC lint. If the tuner is a tube type, the bias is negative; If solid state, a positive voltage is generally applied.
3. If the tuner has an RF test point, connect the red lead from the 39G23 detector probe to this point. Some tuners use the IF output jack, requiring a demodulator probe. Use the Blue lead from the 39G23 at this point.
4. Connect the scope vertical input lead to the SCOPE VERT jack and the scope horizontal to the Scope Horiz jack on the SM158.
5. Set the SM158 Sweep output switch and the TV tuner to channel 10.
6. Depress the VIDEO CARRIER marker button and the SOUND CARRIER marker button. The curve should appear as shown in figure 18. The fine tuning of the TV tuner may have to be adjusted slightly to bring the response curve and markers to the right point as shown.

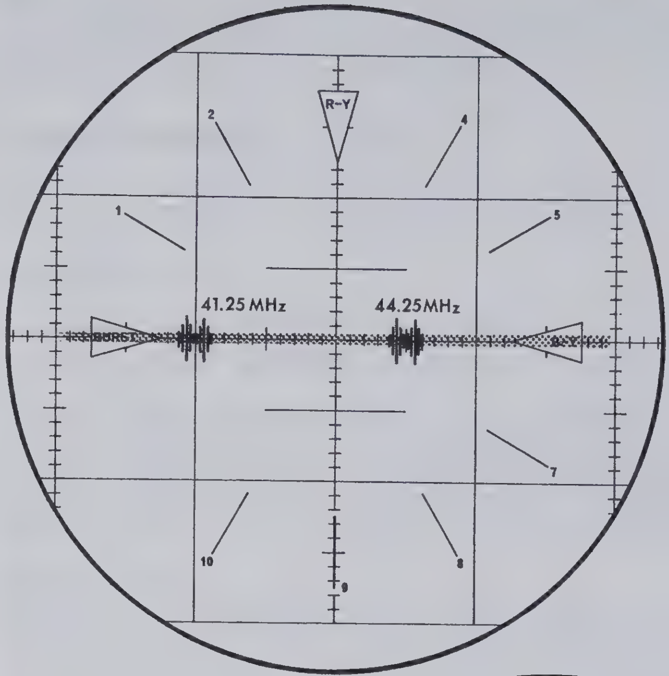


Fig. 16

CALIBRATION OF SCOPE SCREEN

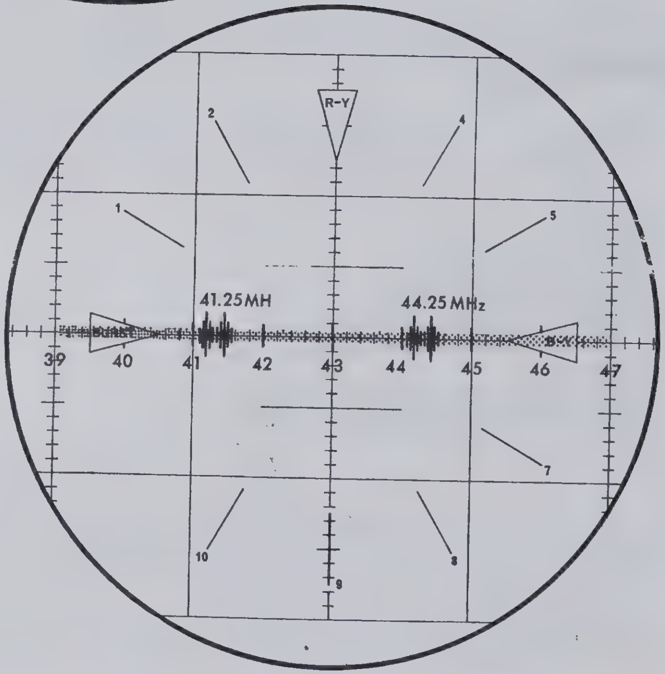


Fig. 17

CALIBRATION OF SCOPE SCREEN IN EVEN MHz

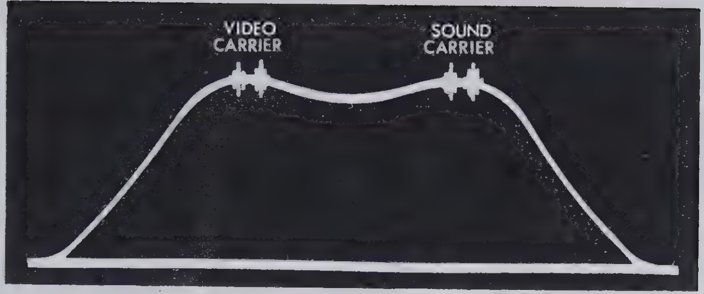


FIGURE 18 IDEAL RF RESPONSE CURVE OF TUNER

Channels 3, 4 and 13 may be checked in the same manner. If any channel required adjustment, the converter grid trimmers or RF trimmers can be touched up to give the proper display on the scope screen.

MAINTENANCE

DISASSEMBLY INSTRUCTIONS

For calabration and other internal adjustments, the SM158 must be removed from its case. To remove the SM158 Speed Aligner from its case, follow these simple steps:

1. Set the SM158 face down on the bench and remove the two screws holding the bottom of the front panel to the case.
2. Remove the two screws holding the cord wrapper to the back of the case.
3. Slowly lift the case away from the chassis and panel. This will expose all the internal parts and adjustments for calabration and maintenance.
4. If the tuner must be worked on, the tuner cover may be pulled off the tuner chassis as it is merely a force fit cover.

AMPLIFIER BOARD

The amplifier board in the tuner may be removed for service if necessary by these steps:

1. Remove the tuner cover.
2. Remove the connector to the amplifier board that are on the top of the tuner.
3. Remove the three screws holding the board to the tuner.
4. Unsolder the filter lead at the corner of the board and it is now free for removal from the tuner.

If only the dual gate MOSFET is to be replaced, the amplifier board does not have to be removed from the tuner. The MOSFET is mounted in a socket and merely removing the tuner cover exposes it for replacement.

When servicing the MOSFET, observe caution as static charges can damage it very easily. Be sure you are touching the chassis when you remove it from the socket and short the leads together with a piece of wire before letting ho of the MOSFET case.

ALIGNMENT INSTRUCTIONS

The SM158 Speed Aligner is very easy to calabrate and align if it ever becomes necessary. Follow the procedure below;

Equipment Needed:

1. Oscilloscope such as the Sencore PS148
2. RF volt meter or demodulator probe and Field Effect Meter

Preliminary set up and connections: Set the SWEEP OUTPUT switch to IF, all marker buttons out so that the markers are in the off positions, the SWEEP HEIGHT to minimum or fully counter clockwise and the MARKER HEIGHT to minimum or fully counter clockwise. Connect the SCOPE VERT jack and SCOPE HORIZ jack from the SM158 to the oscilloscope.

POWER SUPPLY
Connect a field effect meter to the plus 24 volt output on the power supply load, see figure 22. Adjust R216, the 24 volt adjust until the meter reads 24 volts. Temporarily connect a 1200 ohm 1 watt resistor from the plus 24 volt point to ground. The meter should now read 23 volts. If the meter reads higher or lower, adjust R213, the current limit adjust until the meter reads 23 volts. Disconnect the resistor.
It is important that the power supply be checked and reset of necessary before any other alignment of the Speed Aligner is preformed. A change in power supply voltage can effect both the tuning and output on the Speed Aligner.

RF OUTPUT
The minimum and maximum output from the Speed Aligner are set with R209 and R201 respectively. The best indication is with an RF voltmeter, setting R201 for about .3 volts with the SWEEP HEIGHT control to maximum and R209 for zero output with the SWEEP HEIGHT to minimum.

Using a demodulator probe such as the Sencore 39G3 and a field effect meter, a DC voltage of .5 to .55 will indicate approximately .3 volts of RF.

MARKER ALIGNMENT

Each marker can be adjusted in amplitude slightly by tuning of its associated transformer. See figure 19. Since the markers are actually crystal controlled oscillators, the frequency can not be shifted with this adjustment enough to effect alignment. If a marker is not present when the button is depressed and it will not come on when the transformer is tuned, then the oscillator circuit itself must be checked out for the trouble.

SWEEP WIDTH

To adjust the sweep width, depress the 39.75 and 47.25MHz buttons. Adjust the trace on the scope screen for 4 inches in length. With the front panel FINE TUNING control and the internal sweep width control R203, place the 47.25MHz marker on the extreme right hand side and the 39.75MHz marker in the center of the screen. By working both controls, this can easily be done. See figure 19 for location of the controls.

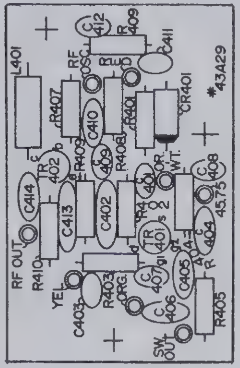

RF OUT
RF OSC
SW OUT
YEL
ORG
WT.
45.75
*43A29
L401
C411
CR401

Fig. 21 RF amplifier layout

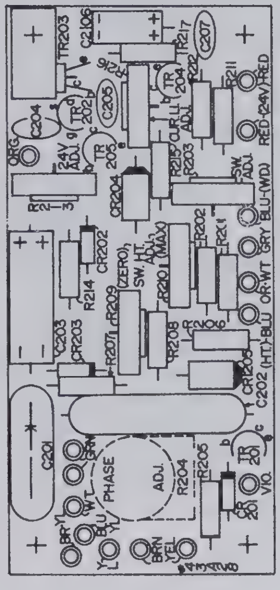

TR203
24V ADJ.
CURLL ADJ.
SW ADJ.
RED-(24V)-RED
GRY BLU-(WD)
OR-WT
C202 (HT)-BLU
PHASE
ADJ.
R204
ORG
BRN
YEL
VIO.
BRY
BLU
WT.

Fig. 22 Power supply PC board layout

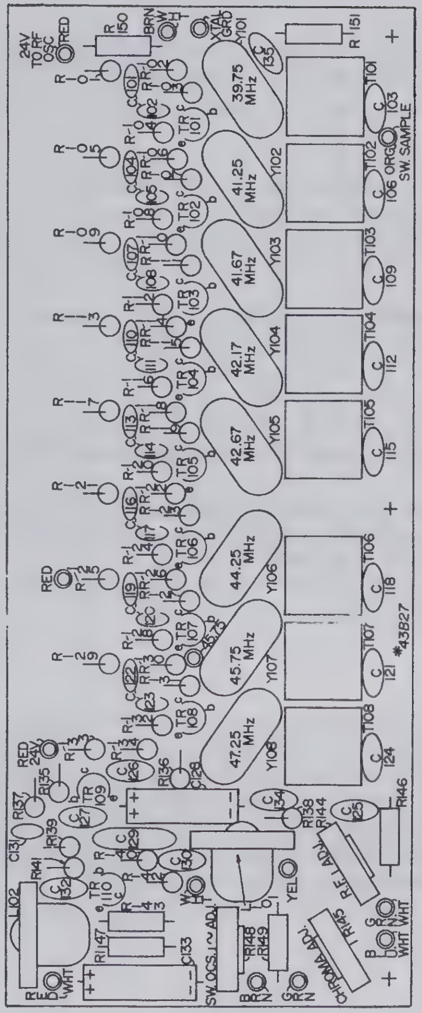

24V TO RF OSC
RED
BRN
WHT
XTAL GRD
39.75 MHz
41.25 MHz
41.67 MHz
42.17 MHz
42.67 MHz
44.25 MHz
45.75 MHz
47.25 MHz
SW. SAMPLE
*43B27
SW OCS. ~ ADJ.
CHROMA ADJ.
R.F. ADJ.
YEL
WHT WHT

Fig. 19 Marker PC board layout

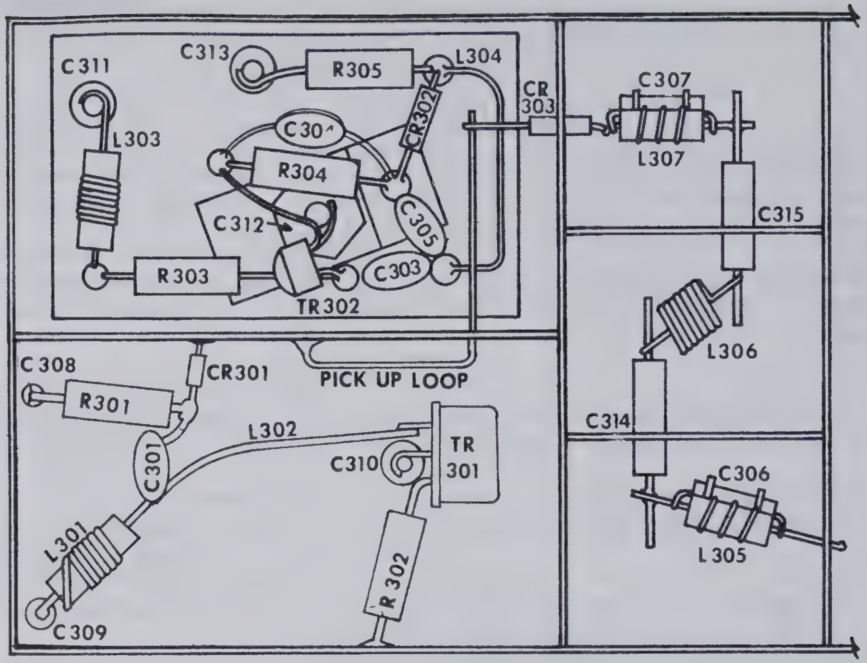

C311
C313
R305
L304
CR 303
C307
L307
L303
C30^
R304
CR302
C312
C305
R303
C303
TR302
C315
L306
C308
CR301
PICK UP LOOP
R301
L302
TR 301
C314
C306
C301
C310
L301
R 302
L 305
C 309

Fig. 20 UHF oscillators and filter layout

SWEEP FREQUENCY

The output frequency is controlled by 2 UHF oscillators beating together to form a fundamental output in the TV IF range. The frequency of the oscillators can be shifted with R144 RF ADJ and R148 SWEEP FREQ ADJ to re-center the output if it drifts or a componant has been changed in the UHF oscillators. For normal service, these controls will not be used. If you replace a transistor for example in the UHF oscillator, the output frequency must be reset. Depress all the marker buttons and set the front panel FINE TUNING control to its midpoint. Adjust the two controls, R144 and R148 to center the markers on the scope screen.

CHANNEL 3, 4, 10 AND 13 ADJUSTMENTS

The RF coils maybe adjusted with a field strength meter such as the Sencore FS134 or using a good working television receiver. With the field strength meter set to the proper channel, each coil is adjusted for maximum indication with the SWEEP WIDTH set to minimum.

If a T. V. receiver is used, the SM158 is connected as for an overall alignment check. Each coil is tuned on its respective channel for a response curve similar to that shown in figure 8. Be sure the T. V. fine tuning is set to the center of its range on each channel.

It is possible to tune channel 3 to 2 or 4 to 5 if you desire with the above method.

CIRCUIT DESCRIPTION

The SM158 Speed Aligner comgines Sencore experience with modern technology to make the ultimate in sweep generators that operate with ease and accuracy.

The two UHF oscillators, TR301 and TR302 form the basis of the SM158. The 44MHz basic sweep is created the difference frequencies of the two oscillators. Both are DC controlled with varicap diodes CR301 and Cr302. TR301 is the fixed oscillator, but its output frequency can be adjusted slightly with the front panel FINE TUNING control. TR302 is the swept oscillator and a 60 Hertz signal is fed into the base from TR201 blanker stage in the power supply.

The difference frequency passes through the three section low pass filter to greatly reduce the UHF frequencies passed into the RF amplifier stage. The output of the filter is also coupled into the marker buss line on the marker board.

The RF amplifier, TR401 is a dual gate MOSFET. The difference signal of 44MHz swept is applied to the first gate and a DC voltage to the second gate. The D. C. voltage is used to control the gain of the amplifier and therefore the output RF signal from the SM158.

TR402 Acts as an amplifier, and impedance match to the RF output jack and as a mixer for the 4 VHF RF signals. In IF, TR402 acts as an amplifier and matching stage. When the switch is on channel 3, 4, 10, or 13, it mixes the 44MHz swept signal with the RF signal from TR1. TR1's output frequency is combined with the 44MHz swept signal to produce an RF swept signal on the desired channel for overall alignment checks and tuner alignment.

The markers are generated by mixing the output of the crystal controlled marker oscillators with the sample of 44MHz swept signal. The two signals are combined and the audio beat detected in TR109. TR109 and TR110 act as an amplifier, increasing the amplitude of the signal and coupling it to either the SCOPE VERT jack or SCOPE HORIZ jack depending upon the position of S2. S2 is a push pull switch mounted on the back of R1, the marker amplitude control.

The power supply is a 24 volt regulated and current limiting supply. TR203 is a standard pass transistor and TR205 an error amplifier. The base of TR205 is set up to provide 24 volts at the output. If the current drain exceeds 100mA, then the current limiter, TR204 decreases the bias on TR205, reducing the output voltage, thereby reducing the current from the supply. This protects the power supply and componants if a short should occur in the 24 volt line in the generator. A .2 amp fuse in the primary of the power supply protects the power transofrmer in the SM158.

TROUBLE CHART

TROUBLE	CAUSE AND ACTION
No Response curve but all markers visable	Check TR401 and TR402, in tuner for defective transistor. Check CR401 diode for open or short. Check connections to tuner for open.
No Response Curve or markers visable	Check 24 volt power supply for low or absent output. Check TR301 and TR302 in tuner, may be defective. Check CR303 for open & shorted condition.
Response curve but no markers	Check sweep sample connections from tuner. Check birdie amp. TR109 or TR110 may be defective.
No RF response curve, but good IF curve	Check S3 for defective contacts TR1 may be defective.
Some markers missing	Check tuning of transformer and transistor for defect. Check switch contacts for dirt. Use good tuner cleaner on switch contacts.
Response curve on IF but not on chroma	Check 45.75 MHz input to tuner. Check diode in 39G23 detector probe for open or short.
Unit completely dead	Check .2 amp fuse on rear of SM158.

SCHEMATIC AND PARTS LIST
FOR
SM158

Speed Aligner

REFERENCE NO.	PART NO.	DESCRIPTION	PRICE
CONTROLS			
R1 & S2	15B6-2	20K pot w/push pull switch	1.90
R3	15C1-11	2K bushing mt. carbon	1.50
R4	15C-15	10K bushing mt. carbon	1.50
R5	15C1-22	5K bushing mt. carbon	1.50
R144, 145, 213, 216	15C7-14	5K VERT P.C. MT.	.75
R148	15C7-2	10K VERT P.C. MT	.75
R203	15C7-13	100K VERT P.C. MT	.75
R204	15C7-16	5K HORIZ P.C. MT.	.75
R209, 210	15C7-17	1K VERT P.C. MT.	.75
SEMICONDUCTORS			
TR1, 402	19C7-1	SE3002 TRANSISTOR	1.50
TR101 thru TR108	19C7-1 or 19C15-1	SE3002 or 2SC684 TRANSISTOR	1.50
TR109, 110, 201, 204, 205	19C4-1	2N5172 TRANSISTOR	.50
TR202	19C6-1	2N5163 FET	1.50
TR203	19C10-1	2N3405 TRANSISTOR	2.00
TR301	19C13-1	2N3866 TRANSISTOR	4.00
TR302	19C7-2	SE3005 TRANSISTOR	1.50
TR401	19C2-1	3N140 MOSFET	4.50
CR201	50C3-1	DIODE, 1N34A	.50
CR202, 203	16S10	RECTIFIER 1AMP 400PIV	1.50
CR204	50C4-2	ZENER DIODE, 8.2V, 1W	1.35
CR205, 401	50C4-3	ZENER DIODE, 12V, 1W	1.35
CR301	50C11-1	DIODE, VARICAP, BA141	4.00
CR302	50C6-1	DIODE, VARICAP, MV1620	3.00
CR303	50C3-3	DIODE, 1N82A	1.50
	50C3-4	DETECTOR DIODE 1N774	.75

CAPACIATORS

C1	24G129	1000vfd@40V LYTIC	2.00
C201	24G222	.47ufd@100V POLY	.60
C202	24G160	1utd@200V MYLAR	.65

SWITCHES

S1	25G124	DPDT LIGHTED SLIDE	1.50
S2	(PART OF R1 CONTROL)		
S3	25A140	6P6P ROTARY	4.00
S101	25B118-2	8 SECTION PUSH/PUSH SWITCH	10.00

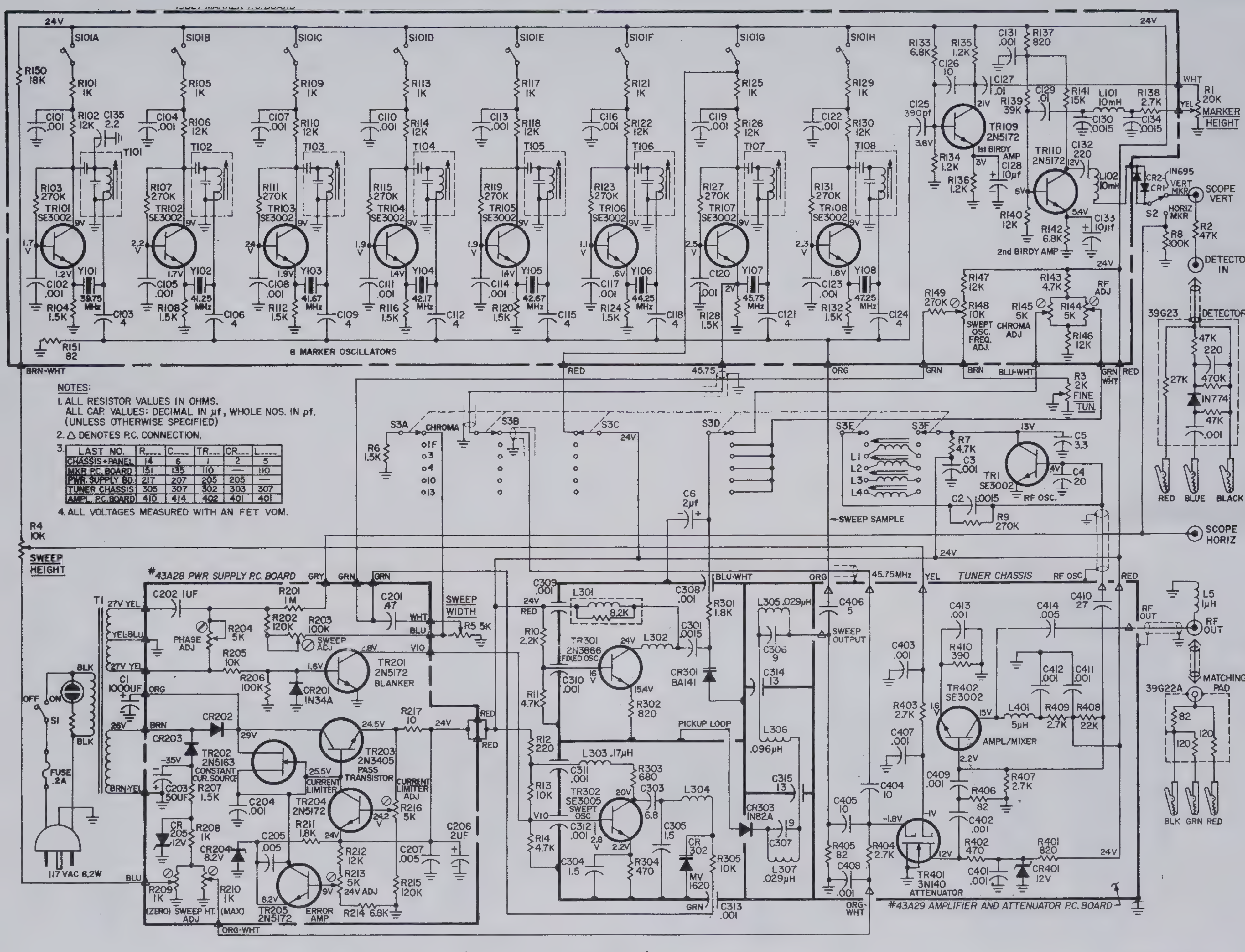
CRYSTALS

Y101	47G9	39.75 MHz CRYSTAL	5.00
Y102	47G10	41.25 MHz CRYSTAL	5.00
Y103	47G11	41.67 MHz CRYSTAL	5.00
Y104	47G12	42.17 MHz CRYSTAL	5.00
Y105	47G13	42.67 MHz CRYSTAL	5.00
Y106	47G14	44.25 MHz CRYSTAL	5.00
Y107	47G7	45.75 MHz CRYSTAL	6.00
Y108	47G15	47.25 MHz CRYSTAL	5.00

MISCELLANEOUS

	26G114	75 ohm COAX JACK	1.00
TR101 thru TR108	28C28	40MHz TRANSFORMER	1.50
	28C42	POWER TRANSFORMER	6.00
L1, 2	46A30	CHANNEL 3 & 4 RF COIL	.75
L3, 4	46A48	CHANNEL 10 & 13 RF COIL	.75
L5	46G19	1uH CHOKE	.30
L101, 102	46G19	10mH CHOKE	1.00
L301	46A49	RF CHOKE ON 8.2K	.30
L303	46A26	.17uH CHOKE	.30
L305, 307	46A37	.029 uH CHOKE	.30
L306	46A38	.096uH CHOKE	.30
L401	46G6	6uH CHOKE	.30
	SC8B40	FRONT PANEL	7.00
	SC8B41	ESCUTCHEON	3.00
	10B257	TUNER COVER	1.00
		CASE COMPLETE	16.00
		RF CABLE	1.50
	39G23	DETECTOR CABLE	7.95
	39G22A	MATCHING PAD	5.95

SENCORE
3200 Sencore Drive
Sioux Falls, South Dakota 57107


8 MARKER OSCILLATORS
S101A
S101B
S101C
S101D
S101E
S101F
S101G
S101H
Y101 39.75 MHz
Y102 41.25 MHz
Y103 41.67 MHz
Y104 42.17 MHz
Y105 42.67 MHz
Y106 44.25 MHz
Y107 45.75 MHz
Y108 47.25 MHz
TR101 SE3002
TR109 2N5172 1st BIRDY AMP
TR110 2N5172
2nd BIRDY AMP
R1 20K MARKER HEIGHT
SCOPE VERT
SCOPE HORIZ
DETECTOR IN
39G23 DETECTOR
1N774
RED BLUE BLACK
S2 VERT MKR HORIZ MKR
R3 2K FINE TUN
R144 5K RF ADJ
R145 5K CHROMA ADJ
R148 10K SWEPT OSC. FREQ. ADJ.
S3A CHROMA
S3B
S3C
S3D
S3E
S3F
L1 L2 L3 L4
TR1 SE3002 RF OSC.
SWEEP SAMPLE
R4 10K SWEEP HEIGHT
#43A28 PWR SUPPLY P.C. BOARD
T1
C1 1000UF
117 VAC 6.2W
FUSE .2A
S1 OFF ON
R204 5K PHASE ADJ
R203 100K SWEEP ADJ
TR201 2N5172 BLANKER
CR201 1N34A
R5 5K SWEEP WIDTH
TR202 2N5163 CONSTANT CUR. SOURCE
TR203 2N3405 PASS TRANSISTOR
TR204 2N5172 CURRENT LIMITER
R216 5K CURRENT LIMITER ADJ
R213 5K 24V ADJ
TR205 2N5172 ERROR AMP
R209 1K (ZERO) SWEEP HT. ADJ
R210 1K (MAX)
TUNER CHASSIS
TR301 2N3866 FIXED OSC
TR302 SE3005 SWEPT OSC
CR301 BA141
CR302 MV1620
CR303 1N82A
PICKUP LOOP
SWEEP OUTPUT
45.75MHz
RF OSC
RF OUT
TR402 SE3002 AMPL/MIXER
TR401 3N140 ATTENUATOR
#43A29 AMPLIFIER AND ATTENUATOR P.C. BOARD
39G22A MATCHING PAD
BLK GRN RED

NOTES:

1. ALL RESISTOR VALUES IN OHMS.
ALL CAP. VALUES: DECIMAL IN µf, WHOLE NOS. IN pf.
(UNLESS OTHERWISE SPECIFIED)
2. △ DENOTES P.C. CONNECTION.
3.

LAST NO.	R____	C____	TR___	CR__	L____
CHASSIS+PANEL	14	6	1	2	5
MKR P.C. BOARD	151	135	110	—	110
PWR. SUPPLY BD.	217	207	205	205	—
TUNER CHASSIS	305	307	302	303	307
AMPL. P.C. BOARD	410	414	402	401	401

4. ALL VOLTAGES MEASURED WITH AN FET VOM.

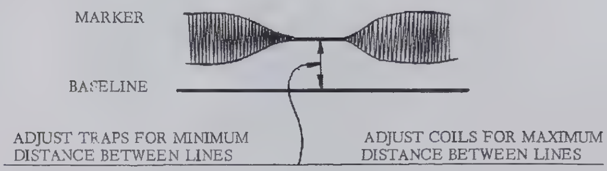
SM158 'SPEED ALIGNER' SCHEMATIC

ISSUE DATE: 8-24-70

IF SPOT-ALIGNING WITH THE SM158 SPEED ALIGNER

In many cases the receiver to be aligned will be badly mid-aligned due to component changes or someone tampering with the adjustment. To facilitate the alignment of this receiver, the coils and traps can be preset near their correct alignment point by "spot-aligning." Spot-aligning is nothing more than adjusting each coil for maximum response at its specified operating frequency and adjusting the traps for minimum response. A single frequency RF generator or equivalent is necessary to perform the spot-alignment.

The following procedure will allow spot-alignment using the SM158. The SM158 connections will be the same as for IF alignment given on page 14 of the Service Manual. Depress the marker push button of the frequency to be used for coil or trap adjustment. While observing the response of the oscilloscope, adjust the Sweep Width to minimum (counterclockwise rotation) keeping the marker in the center of the scope display by adjusting the SM158 Fine Tuning Control. The display obtained should appear as illustrated below.


MARKER
BASELINE
ADJUST TRAPS FOR MINIMUM DISTANCE BETWEEN LINES
ADJUST COILS FOR MAXIMUM DISTANCE BETWEEN LINES

This procedure will provide on RF output signal, without sweep, at the exact frequency of the crystal marker. To set traps, follow the above procedure using marker corresponding to the trap frequency and adjust the trap to reduce the spacing between the two horizontal lines to minimum. (See illustration) When setting traps, increase Sweep Output as separation between lines decreases. To peak coils, follow the above procedure using the marker corresponding to the coil frequency and adjust for maximum separation between horizontal lines. (see illustration) When peaking coils, maintain a low level of Sweep Output so that the receiver does not become overloaded. In the event that a marker is not available at the exact frequency, use the closest marker frequency available. After spot-alignment, proceed with the overall IF alignment.

UHF SWEEP OUTPUT WITH THE SM158 SPEED ALIGNER

After a receiver has been adjusted for overall IF response, a check should be made to determine whether or not the UHF and VHF tuners have the proper bandpass and response. These checks should be made to eliminate the possibility of a defective or misaligned tuner creating additional problems. The UHF and VHF RF/IF overall response check will also provide a quick and efficient means of isolating the tuner as a source of problems in a receiver being serviced. The VHF RF/IF overall response check procedures are given on Page 12 of the SM158 Service Manual.

Although not specifically called out by a front panel switch position, a UHF sweep output is also available at the RF output jack. To obtain this output, it is only necessary to position the Sweep Output switch in the IF position. Connections for the UHF RF/IF overall response check are the same as shown in Figure 8 of the Service Manual except for the RF cable and 300 ohm matching pad. The connection for the RF cable and pad is made to the UHF antenna terminals of the receiver or directly to the input terminals of the UHF tuner. Tune the UHF tuner to channel 41. (The exact setting of the UHF tuner will vary somewhat depending on the accuracy of the channel indicator associated with the UHF tuner.) The overall response curve should be similiar to the IF overall response curve or the curve shown in Figure 9 of the Service Manual.

SENCORE
NO. 1 MANUFACTURER OF ELECTRONIC MAINTENANCE EQUIPMENT
3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

ANALOG POINTING AND DIGITAL MULTIMETER

MODEL A-445

INSTRUCTION MANUAL

PROTEK

- If switching from a Ω function to a V function shortcircuit VΩ and COM terminals to quickly reset the pointer to zero.

3.4. TO REPLACE THE FUSES

Select the appropriate type:
2A(5×20mm/250V)

Warning : A wrong fuse replacement will endanger the meter safety.

3.5 MEASUREMENTS

3.5.1 DC VOLTAGE MEASUREMENT

- Connect red and black leads to VΩ and COM terminals respectively.
- Set the range/function selector switch to the appopriate V DC range from 1000V down to 200mV.

Note : For unknown values start with 1000V then decrease progressively for maximum resolution (maximum number of digits after the decimal point).

(1) Overflow 20-25×range factor : extension for analog reading only (scale 0-25)

(2) Digital reading capacity reduced to 1000 counts

3.5.2 AC RMS VOLTAGE MEASUREMENT

- Connect red and black leads to VΩ and COM terminals respectively.
- Set the range/function selector switch to the appropriate V AC range 750V down to 200mV

Note : For unknown values start with the 750V then decrease progressively for maximum resolution(maximum number of digits after the decimal points).

(1) Overflow 20-25×range factor : extension for analog reading only (scale 0-25)

(2) Digital reading capacity reduced to 750 counts
Analog reading reduced to 750 (red-mark-on scale 0-1000)

3.5.3 DECIBELMETER

- Reference : 0dB=775mV/600Ω on 2V AC range.
- Connect red and black leads to VΩ and COM terminals.
- Set the Function selector switcn to dB.
- Set the range selector switch to either 200V AC, 20V AC, 2V AC, or 200 mV AC range (start with the 20[illegible])
- Reading is direct with reference to the 2V AC range only.
- Reading of two levels allows measuring ratios in dB's

Digital reading (✱)		Analog reading (✱)	
2V AC(dB) +15−25counts	2V AC(AC) 2000counts	2V AC(dB) direct	2V AC(AC) scale 0−25 (V÷10)
−025(1) −020 000 +010 +015(1)	.043V .077V .775V 1 (2) 1 (2)	(3)25 (3)20 0 (3)10 (3)15	0.43(43.6mV) 0.77(77.5mV) 7.75(775mV) 24,55(2,455V) (4) (4,365V)
(1)reduced accuracy accuracy as indicated page 6	(2)overflow 3zeros +decimal point blanked	(3)add sign accordinng to digital reading on dB	(4)pointer at scale end

(*) The negative sign displayed must be taken in account

3.5.6. RESISTANCES MEASUREMENT

- Connect red and black leads to VΩ and COM terminals.*
- Set the range/function selector switch to one of the 20MΩ to 200Ω ranges.

Note : For unknown resistances start on the 20MΩ then decrease progressively for maximum resolution (maximum number of digits after the decimal point).

- Measure resistance with all voltages disconnected from the terminals and read as follows.

Ranges	Analog reading	Digital reading	Digital resolution
200Ω(1)	Ω×10 scale 0−25(2)	199.9Ω	100mΩ
2kΩ	kΩ×0.1 scale 0−25(2)	1.999kΩ	1Ω
20kΩ	kΩ×1 scale 0−25(2)	19.99 kΩ	10Ω
200kΩ	kΩ×10 scale 0−25(2)	199.9 kΩ	100Ω
2MΩ	MΩ×0.1 scale 0−25(2)	1.999MΩ	1KΩ
20MΩ	MΩ×1 scale 0−25(2)	19.99 MΩ	10kΩ

(1) For continuity check on 200Ω range : the circuit to be tested is placed across the VΩ and COM terminals
Moreover for fast short-circuit indication, a buzzer indication is given to the user.
The buzzer is activated when R< 50 Ω across VΩ and COM terminals, and when the operating selector switch is set to •)))

(2) Overflow 20 · 25×(multiplication factor) analog scale only.

Notes:

A- When there is no resistance connected across the input or when an overflow occurs, the pointer is at the end of the full scale deviation and digital display is 1···with three zeros and decimal point blanked.

B- When changing from an Ω function to a V function (open-circuit) short-circuit VΩ and COM terminals so as to speed up the pointer return to zero.

C- Avoid any resistance measurement when voltages are present across the resistance outputs.

3.5.7. DIODES CHECK

- Connect red and black leads to the VΩ and COM terminals.
- Set the range selector switch to ▶|
  The multimeter will display the voltage of the semiconductor junction in volts DC for a 1mA DC
- Reads from .000 to 1.999 V
- If the diode connection is reversed or open circuited overflow will be displayed.

MADE IN KOREA

INSTRUCTION MANUAL FOR PHILCO® CIRCUIT MASTER, MODEL M8100

PHILCO
CIRCUIT MASTER

Famous for Quality the World Over

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The Philco Circuit Master, Model M8100, has been designed not only for general use, but to incorporate features desirable for modern radio and television servicing. The outstanding electrical features are concerned with the reading of a-c voltages. In the majority of vacuum-tube volt-ohmmeters, it has been the custom to read *peak* voltage but to calibrate the scale in the equivalent r-m-s sine wave voltage. When the wave is not a pure sine, considerable error results, because the peak value of a sine wave is 41 percent higher than the r-m-s value. The use of thermocouple or dynamometer type instruments (two generally accepted accurate means of measuring r-m-s voltages) has serious disadvantages in electronic work. However, fairly accurate measurements can be made by using an instrument based on *the average* voltage, which differs from the sinusoidal r-m-s voltage by only 11 percent. Therefore, in the Philco Model M8100, *average* voltages are measured, but the scale is calibrated in the equivalent r-m-s values.

The meter is provided with a scale calibrated in peak voltages, and when used for this purpose, the basic circuit is converted to a peak reading device. When measuring either r-m-s or peak voltages, only the positive portion of the cycle is used. In all a-c measurements, it is the positive half of the sine wave that is utilized to provide meter indication.

The circuit arrangement of the instrument is such that only a single scale is used for a particular function, which removes the confusion resulting from the use of a different scale for the lowest a-c voltage range, as found in many similar instruments.

The attenuator is compensated, for good high-frequency response, up to the 150-volt range.

SPECIFICATIONS

D-C VOLTAGE	
Ranges	1.5, 15, 150, 450, and 1500 volts
Input resistance	10 megohms for all ranges
D-C probe	1 megohm isolating resistor
Polarity	Plus or minus
A-C VOLTAGE AT POWER FREQUENCY (PEAK OR R.M.S.)	
Ranges	1.5, 15, 150, 450, and 1500 volts
Input impedance, with cable	150 uuf., shunted by 5 megohms
AUDIO AND RADIO-FREQUENCY VOLTAGE (PEAK)	
Ranges	1.5, 15, and 150 volts
Input impedance, with cable	150 uuf., shunted by 5 megohms
Frequency response	From 20 c.p.s. to 1 mc., within 2 db
AUDIO-FREQUENCY VOLTAGE (R.M.S.)	
Ranges	1.5, 15, and 150 volts
Input impedance, with cable	150 uuf., shunted by 5 megohms
Frequency response	From 30 c.p.s. to 10 kc., within 2 db
OHMMETER RANGES	
RX1	1000 ohms (center, 10)
RX100	100,000 ohms (center, 1000)
RX1000	1 megohm (center, 10,000)
RX10,000	10 megohms (center, 100,000)
RX1,000,000	1000 megohms (center, 10 megohms)
DECIBELS (BASED ON PEAK VOLTAGES)	
Ranges	5 steps: −20 to +62 db. Zero db is equal to 1.095 volts, peak based on .001 watt across 600 ohms.
GALVANOMETER	Zero on all d-c ranges can be shifted to center of scale for FM discriminator alignment.
ACCURACY (AT 115 VOLTS; 60-CYCLE LINE)	D-C voltage, ±3% of full scale. A-C voltage at power frequency, ±5% of full scale. Audio and radio-frequency voltage, ±5% of full scale. Resistance, ±3% of mechanical scale length. Decibels, ±5% of full scale.
POWER SUPPLY	105 to 125 volts, 50 to 60 cycles.
POWER CONSUMPTION	4 watts at 115 volts, 60 cycles.
HIGH-FREQUENCY PROBE	When used with Philco Part No. 45-1752-1 High-Frequency Probe, range is 15 volts, r.m.s., with frequency response from 10 kc. to 100 mc.
HIGH-VOLTAGE PROBE	When used with Philco Part No. 45-1753-1 High-Voltage Probe, the range is extended to 22,500 volts, d.c.

APPLICATIONS

There are so many applications for the Model M8100 Philco Circuit Master that it is impossible to list all of them in a manual of this size. However, several practical uses are outlined, to give the user an idea of the types of measurements which can be made.

Because of the very high input resistance, true d-c and audio-voltage measurements can be made in relatively high-impedance circuits.

Voltage-gain checks can be made in audio amplifiers, as the d.c. has no effect on a-c measurements of the instrument; this permits measurements to be made in the plate circuits. If the waveform is sinusoidal, accurate gain readings can be made in r-m-s values; but when non-sinusoidal waveforms are present, peak measurements can be made, with assurance that accurate results will be obtained.

A-V-C voltage between the grid of a tube and ground may be measured accurately, by using the –DC VOLTS setting. Push-button tuners may be aligned properly by using the signal from the broadcasting station for an input signal, and by connecting the Circuit Master to the a-v-c bus, as the alignment indicator.

Alignment of the discriminator in FM receivers can be checked by using one of the DC settings and shifting the zero to ZERO CENTER. The instrument is then used as a galvanometer.

CIRCUIT DESCRIPTION

The metering circuit incorporates a 12AU7 dual triode, with the indicating meter connected between the two cathodes. The large amount of negative feedback contributes greatly to the excellent stability of the unit. When measuring d-c voltages or resistance, the triodes operate with a small plate current, in order to keep the grid current exceedingly small. When measuring a-c voltages, the tube operates at a higher mutual conductance. A germanium crystal is used for half-wave rectification of the a-c voltages. The meter responds to the average value of the rectified signal when measuring r-m-s voltages. Peak voltages are obtained by adding a large condenser, to integrate the rectified signals.

The voltage-dividing networks are so designed that the basic meter always operates through the same voltage range, regardless of the RANGE switch setting. It is because of this arrangement that a very high input impedance is obtained for both a.c. and d.c.; the input impedance is independent of the setting of the RANGE switch.

The 12AU7 dual triode functions as a grounded-plate, stage-difference amplifier, with one input fixed. The grid of one tube is the input of the amplifier, and the other grid is kept effectively at ground potential by means of the balancing potentiometers, R27 and R29. The metering circuits are connected between the two cathodes.

When measuring a-c voltages, the two triodes are independent, except for the coupling due to the metering circuit. A change of voltage on the input grid causes a proportionate change of voltage of the associated cathode (pin 3). A voltage difference then results between the two cathodes, and current flows in the metering circuit. This current causes the voltage of the other cathode (pin 8) to vary in the same direction as the cathode voltage of the input triode, but to a lesser degree. The current in the metering circuit is rectified, and a meter indicates the average value of the resulting current. A variable resistor in series with the meter provides a means of adjusting the current to calibrate an r-m-s voltage scale.

For peak voltages, a large condenser is connected across the meter and a variable resistor (R34). The addition of the condenser causes the meter to indicate peak values of the alternating current. The variable resistor provides a means of calibrating the peak voltage range.

When measuring d-c voltages, a balancing potentiometer (R22) is introduced between the negative ends of the cathode resistors. A resistor (R23) is connected between the arm of the potentiometer and the negative supply. Since this resistor is common to both cathodes, some coupling occurs between the two triodes, thus increasing the sensitivity of the amplifier.

The addition of the potentiometer (R22) and common resistor (R23), along with R24 in the bias circuit, changes the operating conditions of the tubes. This potentiometer is for balancing the triodes under new conditions, such as tube replacement.

The meter and another variable resistor (R32) are connected in series between the two cathodes. This provides a means of calibrating the d-c voltage range.

Resistance measurements are made with the tube operating as for the d-c voltage measurements. A 1.5-volt dry cell, in series with a selected resistor, supplies a potential for measurements. A variable resistor (R35), operated from the front panel, is in series with the meter, and is used to adjust the full-scale sensitivity of the circuit. The resistor to be measured reduces the voltage applied to the grid by an amount proportional to the degree of shunting of the battery circuit.

CAUTION: Carelessness in making high-voltage measurements can be fatal. The user is cautioned to observe all possible safety precautions, even to the extent of keeping one hand in the pocket when making connections to high-voltage equipment. The Circuit Master should never be connected to, or disconnected from, a high-voltage circuit while the power to the circuit is turned on.

PRELIMINARY ADJUSTMENTS -

1. Before turning on the Circuit Master, the mechanical zero of the meter should be accurately set by means of the meter adjustment screw.
2. Insert the line-cord plug into a 115-volt, 50 to 60 cycle supply, and turn the CIRCUIT switch to the —DCV position. Allow the Circuit Master to warm up for at least 10 minutes.
3. Set the RANGE switch to the 1500-volt position, and turn the ZERO ADJ. knob in the proper direction to bring the pointer to the scale zero. When measuring d-c volts and ohms, it may be necessary to make a slight readjustment of this control when switching from range to range.

D-C VOLTAGE MEASUREMENTS

Set the CIRCUIT switch to +DCV or —DCV, depending upon the polarity of the voltage to be measured. Plug the black test lead into the jack marked GND, and clip the alligator clip to the common side of the circuit to be measured. Insert the DC VOLTS probe cable plug into the jack marked D.C.V.

The probe can now be applied to the point to be checked.

If the meter deflects to the left, the CIRCUIT switch should be set to the DCV position of the opposite polarity. The RANGE switch should be set to the range which is best suited for the voltage being measured. The electrical zero can be checked at any time after insertion of the probe and lead, by shorting the probe and ground lead together and adjusting the ZERO ADJ. knob to bring the pointer to zero.

Read the voltage on the DC VOLTS scale. For the 150- and 450-volt ranges, read directly. For the 15-volt range, divide the 150-volt scale reading by 10. For the 1.5-volt range, divide by 100; and for the 1500-volt range, multiply by 10.

GALVANOMETER

The Circuit Master is used in the same manner as for d-c voltage measurements, except that the electrical zero is shifted to center-scale. To set the zero, short the d-c probe to the GND lead, and adjust the ZERO ADJ. knob to bring the pointer to the red line marked ZERO CENTER. The RANGE switch varies the sensitivity, as when making d-c voltage measurements. When the meter is used in this manner, the scale calibration is divided by two. For example, when using the 150-volt range, each half of the scale represents 75 volts, and each division is two and one-half volts. The accuracy is slightly impaired when the Circuit Master is used as a galvanometer, but in applications for which this function is usually used, such as in the alignment of a discriminator, a condition of balance, rather than measured deflections, is desired.

A-C VOLTAGE MEASUREMENTS

Set the CIRCUIT switch to RMS or PEAK, depending upon the information desired. Plug the black test lead into the GND jack, and clip the alligator clip to the common side of the circuit to be measured. Screw the AC VOLTS-OHMS probe cable plug into the jack marked A.C.V. OHMS.

The probe can now be applied to the point to be checked. The RANGE switch should be set to the range which is best suited for the voltage being measured. The electrical zero can be checked at any time after insertion of the probe and lead, by shorting the probe and test lead together and adjusting the ZERO ADJ. knob to bring the pointer to zero.

Read the voltage on the RMS or PEAK scale, depending upon the selection of the CIRCUIT switch. For the 150- and 450-volt ranges, read directly. For the 15-volt range, divide the 150-volt scale reading by 10. For the 1.5-volt range, divide by 100; and for the 1500-volt range, multiply by 10.

RESISTANCE MEASUREMENTS

Set the CIRCUIT switch to OHMS. Plug the black test lead into the GND jack. Screw the AC VOLTS-OHMS probe cable plug into the jack marked A.C.V. OHMS. Set the RANGE switch to the desired range. Short the probe and ground lead, and adjust the ZERO ADJ. knob to bring the pointer to zero. Unshort the test leads, and adjust the OHMS ADJ. knob to bring the pointer to the marker at full scale. Connect the probe and ground lead to the two ends of the resistor to be measured. Read the value shown on the OHMS scale, and multiply by the factor on the RANGE switch setting. The RX1 range will not have the same zero setting as the other ranges, because of the resistance of the leads. However, the above adjustments compensate for this resistance, which results in a direct reading.

DECIBEL MEASUREMENTS

The decibel ranges of the Circuit Master are calibrated with reference to peak voltages, based on zero level, equal to .001 watt into 600 ohms. Zero db is equal to 1.095 peak volts.

To measure decibels, connect the Circuit Master to measure PEAK voltages, and read the DB scale. For the 1.5-volt range, the DB scale is direct-reading. For the 15-volt range, add 20 db. For the 150-volt range add 40 db. For the 450-volt range, add 50 db; and for the 1500-volt range, add 60 db.

SERVICE AND ADJUSTMENT

The Philco Circuit Master has been accurately adjusted at the factory, and with normal use should give many years of trouble-free service.

TUBE REPLACEMENT

Although the tube is operated at reduced filament voltage, in time, it may require replacement. The basic amplifier must be rebalanced to the slightly different characteristics of the new tube. The new 12AU7 tube must be one which has been "aged" by operating the filament at rated voltage for 48 hours or longer, with all other elements of the tube disconnected. Tap the tube lightly during the aging period. After replacing the tube, follow the information given below for obtaining a-c and d-c balance.

A-C BALANCE

1. Connect the Circuit Master to a source of 115 volts, 60 cycles. Turn the CIRCUIT switch to DCV, either plus or minus. If, at the end of 30 seconds, the pointer is off-scale, rotate the ZERO ADJ. to bring it anywhere on the scale. Allow the Circuit Master to continue to warm up for approximately 10 minutes, making sure that the pointer remains within the limits of the scale. With the instrument removed from its case, it will be desirable to make the following adjustments with the front panel in a vertical position, for convenience in setting the controls.

2. Set the RANGE switch for 1500 volts, and the CIRCUIT switch to RMS. Set the ZERO ADJ. control and R29 at approximately their mechanical centers. Remove the shield at the tube end of the chassis by loosening the nut holding the DC BAL potentiometer (R22). (The identification of this control is not visible until the shield is removed. It is the control directly below the tube.) Place a jumper across the outer terminals of this potentiometer, and place a jumper across resistor R24, located on the terminal strip adjacent to the tube base.

3. With the pointer set at approximately scale zero, adjust the BIAS control (R25) to make the d-c input cathode (pin 3 of the tube) potential 1.5 volts, with respect to ground. (This voltage should be measured with a 20,000-ohms-per-volt meter.)

4. Set the CIRCUIT switch to +DCV; then rotate the ZERO ADJ. control fully clockwise and note the deflection on the meter.

5. Set the CIRCUIT switch to –DCV; then rotate the ZERO ADJ. control fully counterclockwise and note the deflection on the meter.

6. Adjust the AC BAL potentiometer (R29) to give equal deflections when the two checks above are repeated.

7. Reset the CIRCUIT switch to RMS, adjust the meter pointer to zero, and recheck the voltage at pin 3, which should be between 1.45 and 1.55 volts, d.c., measured with a 20,000-ohms-per-volt meter. If readjustment of R25 is required, to bring the voltages within these limits, it will be necessary to repeat the above procedure.

8. Remove the shorts from R22 and R24. Zero the pointer by means of the ZERO ADJ. control, with the CIRCUIT switch in RMS position. Replace the shield, and tighten the nut on R22.

D-C BALANCE

Without moving the ZERO ADJ. control, adjust the DC BAL potentiometer (R22) until there is no movement of the pointer when the CIRCUIT switch is changed from +DCV to –DCV.

GRID-CURRENT CHECK

With some tubes, the grid current may be excessive, and this will introduce errors in d-c voltage measurements. To check for this condition, set the CIRCUIT switch to –DCV or +DCV, and rotate the RANGE switch from 1500 to 1.5 volts. The meter must not shift from zero by more than 2%. If the shift is greater than this amount, another tube should be tried. No cables are to be connected to the Circuit Master during this test.

CALIBRATION

1. DC: Connect the DC VOLTS probe to a *known* source of voltage between 1 and 1.5 volts. Turn the RANGE switch to the 1.5-volt position, and set the CIRCUIT switch to –DCV. Adjust potentiometer R32, marked DC on the chassis, until the meter reads the proper voltage.

2. RMS: Connect the AC VOLTS-OHMS probe to a *known* source of voltage between 1 and 1.5 volts, r.m.s., sine wave, 60 cycles. Turn the RANGE switch to the 1.5-volt position, and set the CIRCUIT switch to RMS. Adjust potentiometer R33, marked RMS on the chassis, until the meter reads the proper voltage.

3. PEAK: Connect the AC VOLTS-OHMS probe to a *known* source of voltage between 1 and 1.5 volts (60 cycles, or less) positive peak. (A sine wave can be used if the r-m-s voltage is multiplied by 1.414 to give the peak voltage.) Turn the RANGE switch to the 1.5-volt position, and set the CIRCUIT switch to PEAK. Adjust potentiometer R34, marked PEAK on the chassis, until the meter reads the proper voltage.

A-C COMPENSATION

The following adjustments have been made at the factory, and should not require any further attention. However, if any resistors in the a-c voltage-divider network are replaced, it will be necessary to perform these adjustments. The CIRCUIT switch can be in either the RMS or PEAK position.

1. Connect an oscilloscope between ground and lug 11 of the front of wafer No. 2 of the CIRCUIT switch. From a square-wave generator, apply a suitable voltage of 5000 c.p.s. to the AC VOLTS-OHMS probe, and observe the shape of the wave, with the RANGE switch at 1.5.

2. Set the RANGE switch for 150 volts, and increase the voltage from the square-wave generator 100 times. Adjust the trimmer condenser (C3) to give the same waveform as observed in the previous setting.

3. Reduce the voltage of the square-wave generator to 10 times the original value, and set the RANGE switch for 15 volts. Adjust the twist of the two leads (C2), located on the rear of the RANGE switch, to give the same waveform from the 1.5-volt setting.

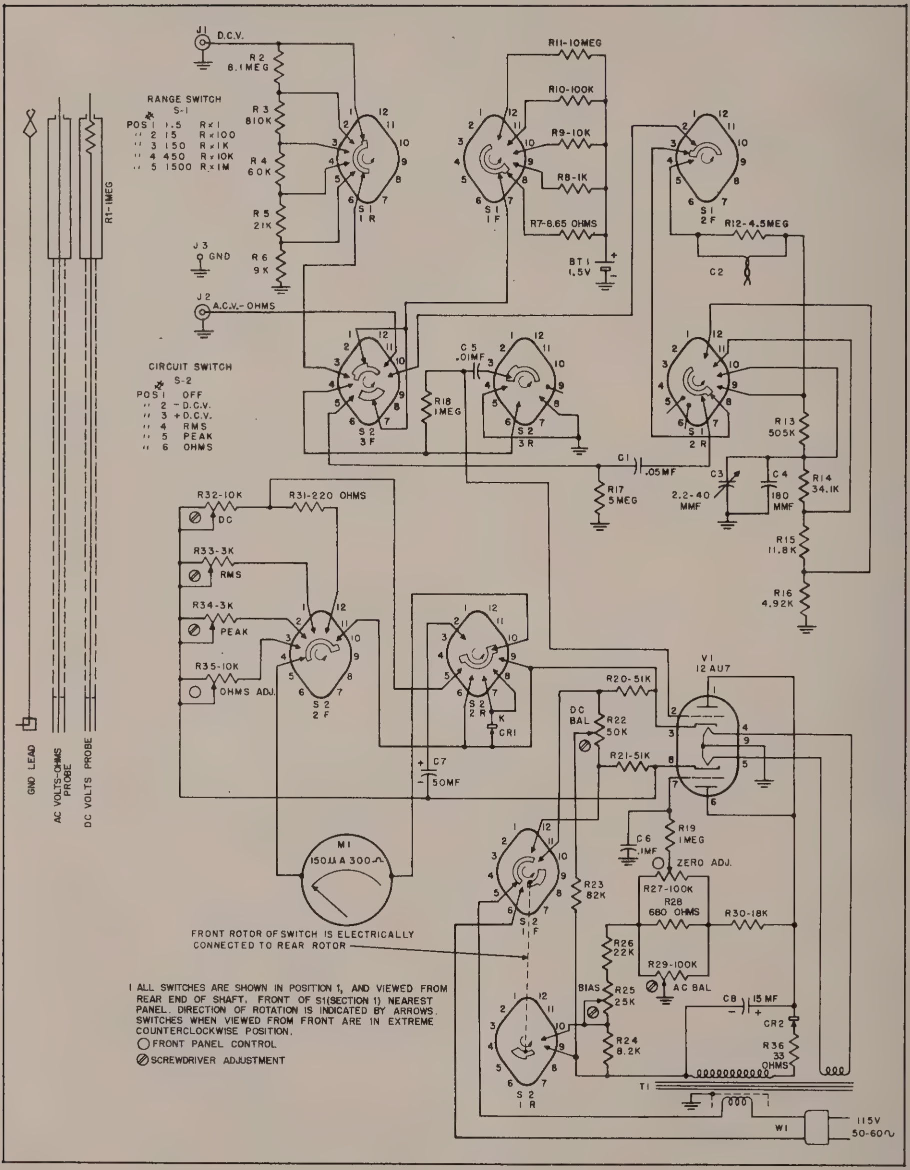
4. Recheck the 150-volt range, and, if necessary, repeat the procedure.

BATTERY REPLACEMENT

The battery should be replaced at least once a year, regardless of its condition. It is suggested that the date of installation be written on the battery. To remove the battery, slide the positive end away from the bracket, and pull it out.

METER REPLACEMENT

To remove the meter, unsolder the leads from the lugs on the back of the meter, but do not remove the terminal screws. Remove the 12AU7 tube and the battery. Loosen the screws made visible, and remove the meter from the panel. When replacing the meter, make certain that the negative side of the meter (black lead) is on the side toward the tube.



J1 D.C.V.
R2 8.1MEG
R3 810K
R4 60K
R5 21K
R6 9K
J3 GND
J2 A.C.V.-OHMS
R1-1MEG
S1 1R
S1 1F
S1 2F
S1 2R
R11-10MEG
R10-100K
R9-10K
R8-1K
R7-8.65 OHMS
BT1 1.5V
R12-4.5MEG
C2
S2 3F
S2 3R
C5 .01MF
R18 1MEG
C1 .05MF
R17 5MEG
C3 2.2-40 MMF
C4 180 MMF
R13 505K
R14 34.1K
R15 11.8K
R16 4.92K
R32-10K DC
R31-220 OHMS
R33-3K RMS
R34-3K PEAK
R35-10K OHMS ADJ.
S2 2F
S2 2R
K CR1
C7 50MF
V1 12AU7
R20-51K
DC BAL R22 50K
R21-51K
M1 150µA 300Ω
C6 .1MF
R19 1MEG
ZERO ADJ.
R27-100K
R28 680 OHMS
R30-18K
R23 82K
S2 1F
R26 22K
R29-100K AC BAL
BIAS R25 25K
R24 8.2K
C8 15 MF
CR2
R36 33 OHMS
S2 1R
T1
W1
115V 50-60∿
GND LEAD
AC VOLTS-OHMS PROBE
DC VOLTS PROBE

RANGE SWITCH
S-1
POS 1 1.5 R×1
" 2 15 R×100
" 3 150 R×1K
" 4 450 R×10K
" 5 1500 R×1M

CIRCUIT SWITCH
S-2
POS 1 OFF
" 2 −D.C.V.
" 3 +D.C.V.
" 4 RMS
" 5 PEAK
" 6 OHMS

FRONT ROTOR OF SWITCH IS ELECTRICALLY CONNECTED TO REAR ROTOR

1 ALL SWITCHES ARE SHOWN IN POSITION 1, AND VIEWED FROM REAR END OF SHAFT. FRONT OF S1(SECTION 1) NEAREST PANEL. DIRECTION OF ROTATION IS INDICATED BY ARROWS. SWITCHES WHEN VIEWED FROM FRONT ARE IN EXTREME COUNTERCLOCKWISE POSITION.

○ FRONT PANEL CONTROL

⊘ SCREWDRIVER ADJUSTMENT

Philco Circuit Master, Model M8100, Schematic Diagram

REPLACEMENT PARTS LIST

REFERENCE SYMBOL	DESCRIPTION	SERVICE PART NO.
BT1	Battery, 1.5v, size C	Philco Battery, Type C
C1	Condenser, paper, .05 uf., 400v	30-4650-45
C3	Condenser, trimmer, 2.2—40 uuf.	31-6473-33
C4	Condenser, mica, 180 uuf.	60-10185417
C5	Condenser, paper, .01 uf., 400v	30-4650-30
C6	Condenser, paper, .1 uf., 200v	45-3505-30
C7	Condenser, electrolytic, 50 uf., 25v	AD1567
C8	Condenser, electrolytic, 15 uf., 150v	30-3035-14
J1	Connector, socket, DCV	27-4617
J2	Connector, socket, ACV-OHMS	27-4617
J3	Jack, GND	27-6299-1
M1	Meter, 0—150 microamperes, d.c.	45-1916
CR1	Rectifier, germanium	34-8022
CR2	Rectifier, selenium	45-1957
R2	Resistor, deposited carbon, 8.1 megohms, 1 w	33-1346-4
R3	Resistor, deposited carbon, 810k, ½ w	33-1346-5
R4	Resistor, deposited carbon, 60k, ½ w	33-1346-6
R5	Resistor, deposited carbon, 21k, ½ w	33-1346-7
R6	Resistor, deposited carbon, 9k, ½ w	33-1346-8
R7	Resistor, wire wound, 8.65 ohms, ½ w	33-1359-1
R8	Resistor, deposited carbon, 1k, ½ w	33-1346-9
R9	Resistor, deposited carbon, 10k, ½ w	33-1346-10
R10	Resistor, deposited carbon, 100k, ½ w	33-1346-11
R11	Resistor, deposited carbon, 10 megohms, 1 w	33-1346-12
R12	Resistor, deposited carbon, 4.5 megohms, 1 w	33-1346-13
R13	Resistor, deposited carbon, 505k, ½ w	33-1346-15
R14	Resistor, deposited carbon, 34.1k, ½ w	33-1346-16
R15	Resistor, deposited carbon, 11.8k, ½ w	33-1346-17
R16	Resistor, deposited carbon, 4.92k, ½ w	33-1346-18
R17	Resistor, deposited carbon, 5 megohms, 1 w	33-1346-14
R18	Resistor, carbon, 1 megohm, ½ w	66-5108340
R19	Resistor, same as R18	66-5108340

REPLACEMENT PARTS LIST (Cont.)

REFERENCE SYMBOL	DESCRIPTION	SERVICE PART NO.
R20	Resistor, carbon, 51k, ½ w	66-3518240
R21	Resistor, same as R20	66-3518240
R22	Resistor, variable, carbon, 50k	33-5565-56
R23	Resistor, carbon, 82k, ½ w	66-3828340
R24	Resistor, carbon, 8.2k, ½ w	66-2828340
R25	Resistor, variable, carbon, 25k	33-5565-57
R26	Resistor, carbon, 22k, 1 w	66-3224340
R27	Resistor, variable, carbon, 100k	33-5565-62
R28	Resistor, carbon, 680 ohms, ½ w	66-1688340
R29	Resistor, variable, carbon, 100k	33-5565-58
R30	Resistor, carbon, 18k, 1 w	66-3184340
R31	Resistor, carbon, 220 ohms, ½ w	66-1228340
R32	Resistor, variable, carbon, 10k	33-5565-59
R33	Resistor, variable, carbon, 3k	33-5565-60
R34	Resistor, same as R33	33-5565-60
R35	Resistor, variable, carbon, 10k	33-5565-63
R36	Resistor, carbon, 33 ohms, ½ w	66-0338340
S1	Switch, rotary, 5-position, 2 sections	42-2002
S2	Switch, rotary, 6-position, 3 sections	42-2003
T1	Transformer, power	32-8626
V1	Tube, 12AU7 (see TUBE REPLACEMENT)	34-2620-1

MISCELLANEOUS

Battery clip	76-8480
Battery spring	28-9118
Case	28-9337
Front panel assembly	76-8479
Handle	28-9338
Knob, ZERO ADJ. or OHMS ADJ.	45-1921
Knob, RANGE or CIRCUIT switch	54-4281
Probe assembly, A.C. Volts-Ohms	45-1955
Probe assembly, D.C. Volts	45-1955-1
Test-lead assembly, common	45-1950-1

STANDARD WARRANTY

"We warrant Philco Test Equipment to be free from defects in material and workmanship under normal use and service, our obligation under this warranty being limited to making good any part or parts thereof which shall, within ninety (90) days after delivery of such product to the original purchaser, be returned to us through our distributor with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied, and of all other obligations or liabilities on our part, and we neither assume nor authorize any representative or other person to assume for us any other liability in connection with the sale of our products.

"In order to receive the benefit of the above ninety (90) day warranty it is required that the product be registered with Philco Corporation. The Registration Card, postage prepaid, attached to this booklet, must be completed and returned to Philco Corporation.

"We reserve the right to make changes in design or to make additions to or improvements upon this product, without incurring any obligation to modify such previously manufactured product.

"This warranty shall not apply to any product which shall have been repaired or altered in any way so as, in our judgment, to affect its stability or reliability, nor which has been subject to misuse, negligence or accident, nor which has had the serial number altered, effaced or removed. Neither shall this warranty apply to any product which has been connected otherwise than in accordance with the instructions furnished by us."

PHILCO CORPORATION
Accessory Division
PHILADELPHIA 34, PA.

Part No. 78-1261 Printed in U. S. A.

SILVER

If zero shifts markedly or "VOMAX" acts unstable, this may be due to an unsheathed or ungrounded a.c. line. A ground connection clipped onto a convenient panel thumb-nut will eliminate effect of "floating" a.c. line

INSTRUCTIONS
FOR
MODEL 900 "VOMAX"

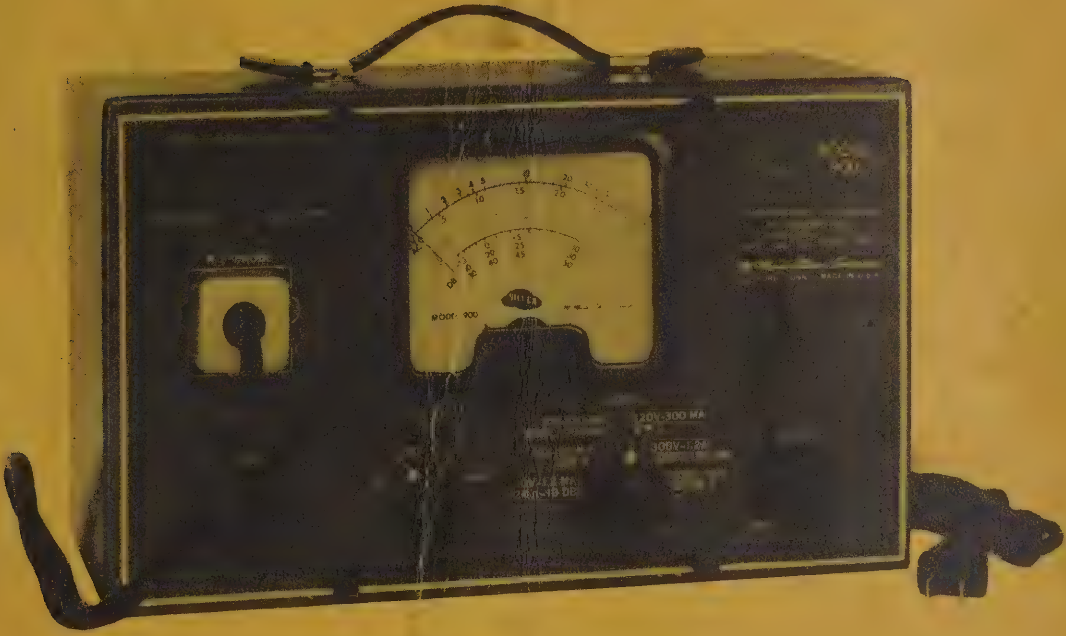


Figure 1

VACUUM TUBE VOLT-OHM-DB-MA-METER
AND
VISUAL DYNAMIC SIGNAL TRACER

INPUT: 105/125 V., 50/60 CYCLE A.C.

OVER 34 YEARS OF RADIO ENGINEERING ACHIEVEMENT

McMurdo Silver Company

1240 MAIN STREET, HARTFORD 3, CONNECTICUT

GENERAL

Model 900 "VOMAX" is a true vacuum-tube voltmeter of new and markedly advanced design. It makes possible d.c. voltage measurement at such astronomically high input resistances as to substantially eliminate loading effects upon sensitive circuits. It provides for a.c. voltage measurements at extraordinarily high meter input resistance throughout the frequency range of 20 cycles to above 100 megacycles. Vacuum-tube resistance ranges cover .2 ohms through 2,000 megohms, while insulation resistance well beyond this range may be measured with the addition of an external battery. Direct currents from 50 microamperes through 12 amperes may be measured. Decibel ranges are from −10 through +50 db. Capacitances over a wide range of commercial values may be measured by the addition of two external rheostats and reference to a chart.

Through new war-born inventions the effects of fluctuations in mains input voltage and of aging of vacuum tubes are practically completely eliminated. The usual deleterious effects of vacuum-tube grid and gas currents heretofore so ruinous of accuracy have been practically eliminated through design features exclusive to "VOMAX".

One knob adjustment sets meter zero for all ranges at start of operation. A second knob establishes full scale ohmmeter set, when resistance ranges may be shifted without requiring re-zeroing.

The name "VOMAX" is basically descriptive of functions — "V" for volts, "O" for ohms, "MA" for milliperes/amperes, and "X" for capacitative reactance, decibels, a.f. and r.f. volts and visual dynamic signal tracing. No such short title can be adequately descriptive of the multitude of ranges and functions which "VOMAX" makes available to the research engineer and serious service technician, not to mention its unusually high accuracy. Stability rivals that of the basic meter movement itself.

ELECTRICAL SPECIFICATIONS

INPUT: 105/125 volts, 50/60 cycles alternating current only. ("VOMAX" may be adapted to higher mains voltages, of frequency between 50 and 60 cycles **only** by a conventional reducing transformer, or by insertion of a series input resistance — 30 watts per 100 volts — in mains cord having total resistance determined upon the basis of 3.46 ohms per volt of increased mains voltage above nominal "VOMAX" input of 115 volts.)

RANGES: Fifty-one effective ranges divided as follows:

- D.C. volts 3, 12, 30, 120, 300 and 1200 at 51 megohms constant input resistance (1 megohm in capacity-isolating test prod). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.
- D.C. volts 7.5, 30, 75, 300, 750 and 3000 at 126 megohms constant input resistance (obtained at Vx2.5 and COM-GND jacks). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.
- A.C. volts 3, 12, 30, 120, 300 and 1200 volts at circuit loading equivalent to 6.6 megohms shunted by 50 mmfd. (diode probe plugged into panel socket). Accuracy ±5%.
- R.F. volts same as A.C. volts but at circuit loading equivalent to 6.6 megohms shunted by 8 mmfd. (diode probe withdrawn for direct contacting to circuit to be measured). Accuracy ±5%.
- OHMS: Six resistance ranges, all zero-left, of 2,000, 20,000, 200,000 ohms and 2, 20 and 2,000 megohms. Accuracy ±2% of full scale, ±1% of indicated resistance.
- DECIBELS: Three db. ranges (0 db. =1 milliwatt in 600 ohms) of −10/+10, +10/+30 and +30/+50 db.
- CURRENT: Six direct current ranges of 1.2, 30, 120, 300 and 1200 milliamperes and 12 amperes. Accuracy ±3%.

FREQUENCY RANGE: 20 cycles through 100 megacycles. "VOMAX" may be employed up to several hundred megacycles with lesser accuracy due to progressively increasing errors occasioned by resonance and transit-time effects in diode rectifier probe.

METER: 4⅝" D'Arsonval movement, 0-1 ma. full scale. Accuracy ±2% of full scale.

MULTIPLIERS/SHUNTS; Multiplier resistors are ±1% matched pairs aged for stability. Current shunts are ±1% wire-wound resistors.

CAPACITORS: Capacitors are hermetically sealed molded-mica, and oil impregnated and electrolytic units hermetically sealed in metal cases. Electrolytic units, though of standard, easily replaceable commercial type, are plug-in through employment of new spring contact clips.

ACCESSORIES: Two Burgess No. 2 1½-volt flashlight batteries for ohmmeter circuit.

One tube complement consisting of 1 — 6AL5 miniature dual diode, 2 — 6SN7GT dual triode cathode follower and meter-actuating tubes, 1 — 5Y3GT (or 5Z4) rectifier.

One red and one black test prods with 48" leads (red prod with reversible tip for a.c. and d.c. voltage measurements).

OVERLOAD PROTECTION: Meter protected against burn-out due to overload on volts, ohms, db., but not on ma/a.

NEW CIRCUIT

The extraordinary stability and dependability of "VOMAX" are due to entirely new and war-born engineering advances. The circuit diagram of Fig. 3 will upon careful study reveal these advanced design features and differences from conventional instruments.

The high order of stability, independence of mains voltage fluctuations and aging of vacuum tubes are obtained by full-balanced circuits in which possible variations in each tube circuit are balanced out by equal and opposite variations in complementary balancing tubes (second sections of each dual tube). Unusually heavy degeneration in each triode circuit, coupled with high diode load resistance, operate to almost completely wash out variations due to voltage fluctuations and tube aging.

The sections of the 6AL5 and 6SN7GT tubes at the top of Fig. 3 comprise the "signal" or measurement circuit. The duplicate sections of these tubes toward the bottom of the diagram constitute the balancing circuits. Each measurement tube is seen to have its companion balancing tube. Three dual-purpose tubes are employed in preference to six single-purpose tubes, since manufactured and processed identically the uniformity between sections of the same tube may be anticipated to be greater over time than can be expected of separate tubes which might be manufactured under markedly different circumstances.

The upper section of the 6AL5 functions as the diode rectifier for a.c. and r.f. voltage measurements, being switched into circuit when so required by ganged switches S1e and S1f. Any diode generates within itself "contact potential" which will produce an initial voltmeter reading. This contact potential is balanced out by that similarly generated within the second diode of the 6AL5 to yield an initial voltmeter zero. Exactly as the contact potential of the upper measurement diode (as well as the rectified a.c. employed to actuate the d.c. voltmeter) is divided down by voltmeter range "stick" R8 through R13 and RANGE switch S2b, so is the balancing potential controlled in step therewith by R2 through R5 and RANGE switch S2c. Initial balance between measurement and balancing contact potentials is established by factory adjustment of R42.

The central 6SN7GT dual triode in Fig. 2 is the cathode follower measurement and balancing tube combination. Operated Class A at very low plate voltage and with extraordinarily heavy degeneration, it explains the unusual freedom of "VOMAX" from usual grid and gas current effects. Its plate voltage is so low as to prevent ionization of residual gas or the appearance of grid current. This is its exclusive and vitally important function. Input voltages are fed to its upper grid through RANGE "stick" R8 through R13 and switches S2B and S1B. In a.c. operation balancing contact potential is fed to its lower grid, which is grounded for all other functions, by switch S1a.

The right hand 6SN7GT tube in Fig. 3 is the meter-actuating triode; top section for measurement, bottom section for balancing. Switches S1c and S1d reverse the meter polarity as required for a.c., d.c.+, and d.c.— measurements, and shift the meter alone over to direct current shunts R27 through R32 and RANGE switch S2e. R34 is the front panel SET-V-ZERO knob, one single adjustment of which sets meter zero for all functions.

Ohmmeter operation involves use of the d.c. vacuum-tube voltmeter comprised by the two 6SN7GT tubes and their associated components switched over to 3-volt dry battery B, ohms RANGE switch S2d and ohms multiplier resistors R14 through R19.

The d.c. voltmeter employed for all voltage and ohms measurements (the two 6SN7GT tubes and associated components) has a basic range of 0-3 volts, which is multiplied to yield higher ranges by 50 megohm "stick" R8 through R13. For the Vx2.5 ranges, 75 megohms (R6, R7) is placed in series with this "stick" and the Vx2.5 panel jack. Switch S2a selects the appropriate factory adjusted wire-wound RANGE SET resistors; R22 for d.c., R23, R24, R25 and R26 for a.c.; and panel ADJ Ω control R33 for setting meter initially to full scale in resistance measurements.

Transformer T and 5Y3GT power supply rectifier develop approximately 360 volts across voltage divider-bleeder R37, R38, R39 and R40, with required filtration accomplished by plug-in capacitors C5 and C6. Half of this voltage is effectively across plate-to-cathode of the right-hand 6SN7GT, approximately 10% thereof on the center cathode follower 6SN7GT. Substantially equal negative voltages developed across R39, R40 operate to offset the large voltage drops across degenerative cathode resistors. R35, R36 and R20, R21 to insure Class A operation of these tubes.

One of the particular advantages of "VOMAX" is that, used as an a.c. or d.c. voltmeter, it can measure its own internal operating voltages. Used as an ohmmeter it can measure its own internal multiplier resistors. It is thus practically self-servicing.

PANEL CONTROLS

The panel nomenclature of "VOMAX" is so self-explanatory as to

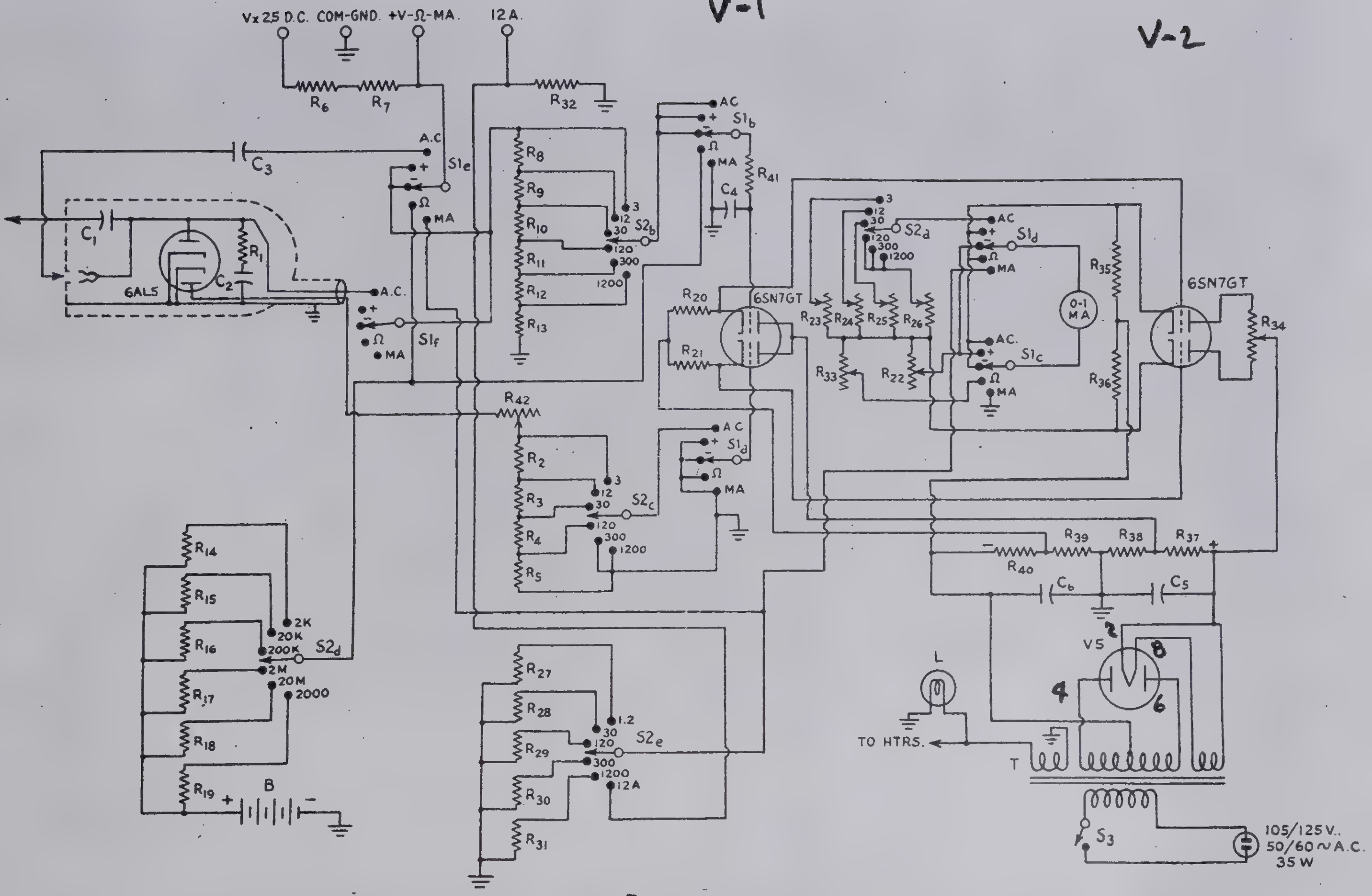


Figure 3

SET resistor for each of these ranges; R23 for 3 volt range, R24 for 12 volt, R25 for 30 volt and R26 for 120 volt range. Adjustment of R26 on the 120 volt range will bring 120, 300 and 1200 volt AC ranges into proper step.

TESTING "VOMAX": The chart appended to Fig. 3 gives voltages correct to 20% which should be observed when the red prod is contacted to the d.c. voltage points listed. Internal a.c. voltages may be similarly measured upon appropriate ranges of "VOMAX" by using both red and black prods to measure mains input voltage, and red prod only for 6.3 volt heater circuits and high voltage power transformer secondaries.

FILTER CAPACITORS: Electrolytic capacitors C5, C6 are polarized. Their + terminals must contact their + spring contactors. Reversal of C5, C6 polarity will ruin them and damage the power transformer and rectifier tube.

CAUTION: HIGH VOLTAGES ARE DEADLY. When measuring high voltages attach black test lead to one side of circuit to be measured, put one hand in pocket, stand on well insulated floor, and holding red test prod lightly between thumb and fore-finger at middle of red prod, contact its tip to high voltage point to be measured. DON'T TAKE CHANCES — YOU HAVE ONLY ONE LIFE — DON'T RISK LOSING IT.

CAUTION: To obtain the extremely useful 1200 volt AC range of "VOMAX" has necessitated operation of the 6AL5 rectifier beyond tube manufacturers' ratings. Extensive tests have revealed no evidence of premature tube deterioration. However, to insure long tube life use the 1200 volt AC range no more than absolutely necessary, and then only briefly. For example, contact prod to source to be measured, read meter, remove prod from source at once.

OPERATING VOLTAGE CHART

Cathode ends of R20, R21 to ground, +2 V d.c.
Cathode ends of R35, R36 to ground, +2 V d.c.
Cathode end of R39 to ground, −17 V d.c.
Cathode end of R40 to ground, −180 V d.c.
Plate end of R38 to ground, +17 V d.c.
Plate end of R37 to ground, +180 V d.c.
Heaters to ground, 6.3 V a.c. (at transformer)
Plates of 5Y3GT to center-tap (tube out of socket) 320 volts a.c.

PARTS LIST

C1 — 0.0005-ufd. silver-mica
C2 — 0.001-ufd. mica
C3 — 0.03-ufd. 3000-volt tubular oil
C4 — 0.005-ufd. mica
C5, C6 — 8-ufd. 350-volt electrolytic
R1 — 20-megohm, ±5 per cent, ¼-watt carbon resistor
R2, R9 — 7.5 megohms, ½ watt metalized resistors*
R3 — 1.5 megohms, ½ watt metalized resistors*
R4, R11 — 750,000 ohms, ½ watt metalized resistors*
R5 — 250,000 ohms ½ watt metalized resistors*
R6, R7, R8 — 37.5 megohms, — watt metalized resistors*
R10 — 3.75 megohms, ½ watt metalized resistors*
R12 — 375,000 ohms, ½ watt metalized resistors*
R13 — 125,000 ohms, ½ watt metalized resistors*
R14 — 10-ohm, 1 per cent ½ watt wire-wound
R15 — 100 ohms, ½ watt metalized resistors*
R16 — 1,000 ohms, ½ watt metalized resistors*
R17 — 10,000 ohms, ½ watt metalized resistors*
R18 — 100,000 ohms, ½ watt metalized resistors*
R19 — 10 megohms, ½ watt metalized resistors*
R20, R21, R41 — 5.1 megohm, ±5 per cent, ½ watt metalized resistor
R22, R23, R24, R25, R26 — 3000 ohm wire-wound potentiometer
R-27 — 258.4 ohm, 1 per cent wire-wound resistor
R28 — 1.758 ohm, 1 per cent wire-wound resistor
R29 — 0.423 ohm, 1 per cent wire wound resistor
R30 — 0.161 ohm, 1 per cent wire-wound resistor
R31 — 0.028 ohm, 1 per cent wire-wound resistor
R32 — Special-Set in test to give 12-ampere range
R33 — 10,000 ohm, wire-wound potentiometer with s.p.s.t. switch
R34 — 3000 ohm wire-wound potentiometer
R35, R36, R37, R40 — 43,000 ohms, ±5 per cent, 2 watt metalized resistors.
R38, R39 — 4,300 ohm, ±5 per cent, ½ watt metalized resistors.
R42 — 10 megohm potentiometer
S1 — 5-position, 6-circuit, 3-section ceramic switch
S2 — 5-circuit, 6-position, 5-section ceramic switch (front section shorting)
T — Power Transformer; 115-volt, 50/60 primary; 5-volts, 2 amp.; 6.3 volts, 1.6 amp.; 640 volts, 50 ma.
*Pairs of I.R.C. BT-½ resistors matched in series to give specified values.

ment preferably includes a tube and coupling transformer, and is most easily made first at one grid, then at the immediately following grid. The gain or loss is the larger voltage observed divided by the smaller.

Because of the inescapable though small input capacitance of any vacuum-tube voltmeter R.F.PROBE, shunting the probe across grid to ground of an r.f. or i.f. stage adds capacity thereto — about 8 mmfd. in the case of "VOMAX" R.F.PROBE contacted directly tip to grid or plate and shell to chassis. This added capacity will slightly detune the circuit being measured and so reduce the voltage appearing across it at the instant of measurement. In preliminary qualitative tests this effect may often be ignored, but for precise measurements the trimmer of the circuit across which voltage is being measured should be adjusted, while the R.F.PROBE is contacted to the circuit, to give maximum voltage reading. The trimmer may be reset by moving the R.F.PROBE along to the next grid circuit and then readjusting the preceding circuit trimmer for greatest voltage reading.

In visual dynamic signal tracing as above the effect of the receivers a.v.c. system must be allowed for. When a strong signal is applied to the antenna input the a.v.c., if functioning properly reduces the gain of each stage enough to hold the i.f. input to the second detector substantially constant. To measure true stage gains the a.v.c. must be rendered inoperative by connecting a jumper from ground to the r.f./i.f. grid side of the first a.v.c. series filter resistor.

From the above it is apparent that a.v.c operation may be accurately checked, and curves plotted if desired, by contacting "VOMAX" R.F.PROBE to the second detector input, retuning the appropriate i.f. trimmer temporarily to give greatest voltage reading, and then reducing antenna input in progressive steps. Plotting a curve of second detector input voltage versus r.f. antenna input voltage gives a basic a.v.c. curve.

In preliminary visual dynamic signal tracing it is convenient to dispense with the necessity of retrimming each circuit measured when the R.F.-PROBE is contacted to it. This is made possible by reducing the 8 mmfd. input capacitance of the R.F.PROBE to some value so low as not to necessitate retrimming. A capacitor of .5 to 1 mmfd. placed in series with the R.F.PROBE tip and the grid or plate to be contacted will reduce R.F.-PROBE capacitance-loading to a value so low as not to significantly upset the tuning of the circuit being measured. Such a capacitance must be as small in physical size as possible. It is most easily obtained by cutting a length of spaghetti insulating tubing of size which will just slip over the R.F.PROBE tip to a length which will completely cover the tip.

This spaghetti sleeve acts as the dielectric of a small capacitor, the plates of which are formed by the R.F.PROBE tip and the socket lug against which the spaghetti (with tip inside it) is contacted. This is a most effective method of simplifying signal tracing. It reduces the sensitivity of the meter considerably, but the 1 volt obtainable from the average local broadcast station or signal generator will usually be sufficient to give a perceptable meter deflection at antenna, first r.f. grid, or certainly at second r.f. grid.

MISCELLANEOUS TESTS

OSCILLATOR VOLTAGE: The strength of oscillation of a superheterodyne or other oscillator may be measured directly in volts with "VOMAX". Contacting the R.F.PROBE to oscillator grid and ground will give a direct indication of the r.f. voltage being developed by the oscillator. It may also be estimated as the negative d.c. voltage developed at the oscillator grid, FUNCTION switch set to DC−, RANGE to appropriate voltage range, and tip in far end of red prod contacted to grid. The first method measures oscillator r.f. voltage directly, the second is indirect and less desirable. By the direct R.F.PROBE method uncertainty is eliminated. Oscillator voltages over each and every band of a receiver up beyond 100 megacycles may be so measured directly.

A.V.C. VOLTAGE: This important class of measurements has been covered under VISUAL DYNAMIC SIGNAL TRACING. A.v.c. voltages are usually negative with respect to chassis ground. FUNCTION knob should therefore be set to DC−, and red prod with tip in far end successively contacted to a.v.c. load resistor, then to each a.v.c.-controlled grid. A stable and reasonably strong input signal should be employed, as from a local broadcast station or signal generator. IT IS CONVENIENT TO CONNECT "VOMAX" ACROSS THE SECOND DETECTOR, OR A.V.C., LOAD RESISTOR IN ALIGNMENT — WHEN ALIGNMENT SHOULD BE EFFECTED TO GIVE GREATEST METER READING.

FM AND A.F.C. DISCRIMINATOR VOLTAGE: The d.c. voltage developed by the discriminator in FM receivers, and in a.f.c. systems, may be measured directly across the discriminator load resistors with "VOMAX". Because this voltage shifts from positive to negative as signal frequency is varied, a zero-center meter is desirable. When properly aligned to a carrier frequency, discriminator output should be zero. Use of a zero-left meter can indicate deviation in only one direction. "VOMAX" can be converted to a zero-center meter for discriminator voltage measurement by simply adjusting the SET V-ZERO knob to bring the meter pointer up to 0 on the db. scale, when deviations in both directions may be readily observed.

TELEVISION RECEIVER VOLTAGE MEASUREMENTS: All types of voltages in television receiver video and audio channels may be measured by "VOMAX". As a peak-reading a.c. voltmeter "VOMAX" is calibrated in R.M.S. values of the sine wave, or .707 of peak value. It may be employed to measure the peak values of sweep oscillator voltages and of saw-tooth or square-wave sources.

AUDIO VOLTAGES: With R.F.PROBE in panel socket, FUNCTION knob at AC and tip in near end of red prod, audio voltages throughout all successive circuits of an audio amplifier may be measured from 20 cycles on up. At high frequencies, and in resistance-capacitance coupled a.f. amplifiers, the effect of the 50 mmfd. input capacitance of "VOMAX" when so used must be allowed for. In making accurate measurements over a wide frequency range it is desirable to do so with the R.F.PROBE directly. However, the 500 mmfd. input capacitor in the R.F.PROBE is so small as to cause error at usual audio frequencies. This may be obviated if one lead from a capacitor of .025 to .1 mfd. is temporarily soldered to the small screw-head found on the R.F.PROBE ceramic head and the other lead of this capacitor used as the probe tip to the circuit under measurement.

SUPERIMPOSED VOLTAGES: D.C. voltages present in a circuit simultaneously with a.c. voltages, and vice versa, can be independently measured by "VOMAX" with no special precautions. When using a.c. functions the series input capacitor blocks out d.c. When using d.c. functions, the a.c. filter R41, C4 filters out a.c.

INSULATION RESISTANCE: Measurement of insulation resistance of capacitors, transformers, reactors and other insulators has been covered under INSULATION RESISTANCE MEASUREMENTS.

PRECAUTIONS: In order to keep input capacitance to a minimum in AC voltage functions of "VOMAX", and to similarly hold down input capacitance in DC operation, the red test lead has not been shielded. In making measurements on high resistance circuits, therefore, the red test lead should be kept away from a.c. mains conduits or wiring. In AC operation, grasp the red prod at its far end, vice versa in DC. Keep the red lead away from the body. Observation of these precautions, coupled with possible grounding of "VOMAX" panel in extreme cases of local electrostatic fields, will avoid errors due to same while keeping meter capacitance at a minimum.

CAPACITANCE MEASUREMENTS: Accurate capacitance measurement is possible only with a bridge circuit which takes into account both capacitance and resistance; which has a dissipation factor or power factor balance. The same is true for inductance measurements. However, rough but useful capacitance measurements may be made in an emergency with "VOMAX". What is so measured is the capacitance reactance, Cx, of the capacitor under test. The method involves connecting the unknown capacitor and a variable resistor in series across a source of 5 to 120 volts of 60 cycle a.c., and adjusting the resistor until the voltage measured across it equals exactly the voltage measured across the capacitor. The resistor is then measured upon the OHMMETER of "VOMAX" and its value located upon Fig. 4, from which point the capacitance may be read directly. One 3000 ohm rheostat and one 3 megohm rheostat will serve for capacitors between 10 and .01 mfd. (When using 50 cycles, true capacitance is ⅚ of the value so indicated.)

MAINTENANCE

Built of the highest quality parts to close to military standards of excellence, no trouble need be anticipated with "VOMAX" over long periods of time. Accuracy will be well maintained even though the same tubes are used in continuous operation for long periods of time. Variation in and aging of tube characteristics have little effect upon operation.

OHMMETER BATTERIES: Ohmmeter batteries should be replaced when they measure less than 2.2 volts total as measured by +DC FUNCTION, 3V RANGE of "VOMAX" itself or when OHMMETER readings become unstable. Connections to batteries should be unsoldered, old batteries removed, new ones inserted and connections thereto resoldered.

VACUUM TUBES: 6SN7GT Vacuum tubes may be replaced when SET V-ZERO knob will not bring meter pointer to zero, or when zero appears unstable even after 10 to 15 minutes warm-up time. Known-good tubes may be directly substituted for original tubes. The same applies to the 6AL5 R.F.PROBE tube. It should be replaced when no adjustment of R42 only will make AC zero coincident with DC zero. If the first replacement 6AL5 tried will not permit establishing AC zero coincident with DC zero through adjustment of R42 alone, a second tube should be tried. If no second tube is available, required coincidence of AC and DC zeros brought about through adjustment of R42 only may be obtained by interchanging the connections to lugs 2 and 7 at the R.F.-PROBE tube socket.

CALIBRATION: Recalibration should practically never be necessary unless the instrument is abused, damaged or its internal RANGE SET resistor adjustments are tampered with. DC calibration may be affected by applying 2 or 3 volts of precisely known d.c. voltage (measured by an external precision laboratory-type meter standard) to the 3V, +DC range of "VOMAX" and then carefully adjusting R22 for identical readings between the external standard meter and "VOMAX" meter. Higher voltage ranges when tested will then be found to be in step.

AC calibration requires an equally good meter having ranges of 2/3, 8/12, 20/30 and 80/120 volts, together with a low-frequency a.c. voltage source within these limits. Having zeroed "VOMAX", calibration consists of applying a definitely known 50 or 60 cycle a.c. voltage to "VOMAX" input, and adjustment of internal a.c. RANGE SET resistors to identicality of meter readings for the four different a.c. voltages on the four meter ranges. Using an external voltage which will give a meter reading somewhere upon the upper ⅓rd of "VOMAX" scale for each of the 3, 12/30 and 120 volt ranges, adjust the appropriate RANGE

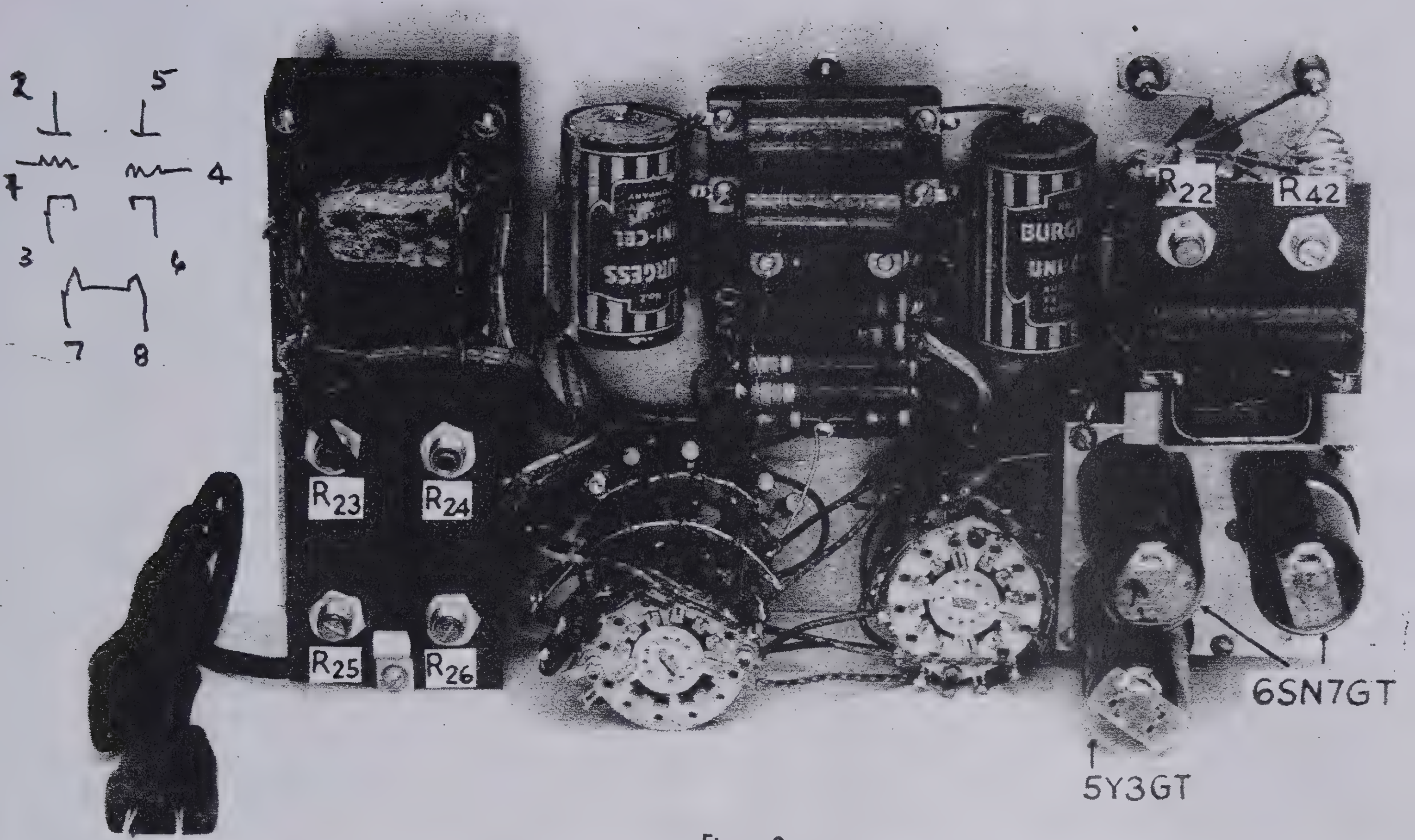
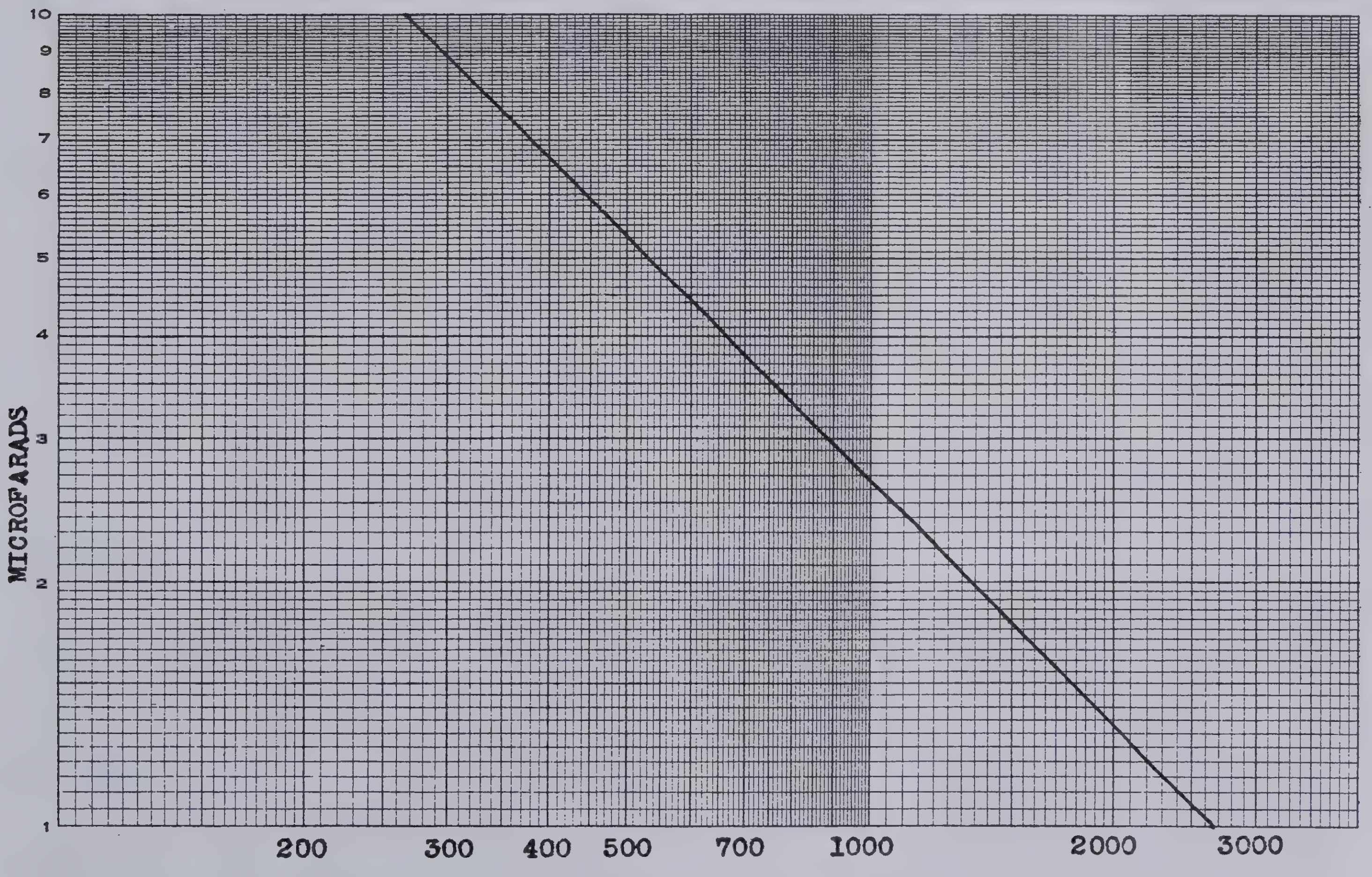

2
5
1
4
3
6
7
8
R22
R42
R23
R24
R25
R26
6SN7GT
5Y3GT
BURGESS
UNI-CEL

Figure 2



FOR EACH ZERO ADDED TO RESISTANCE (BOTTOM SCALE) ADD ONE DECIMAL POINT IN FRONT OF MICROFARADS

FIGURE 4

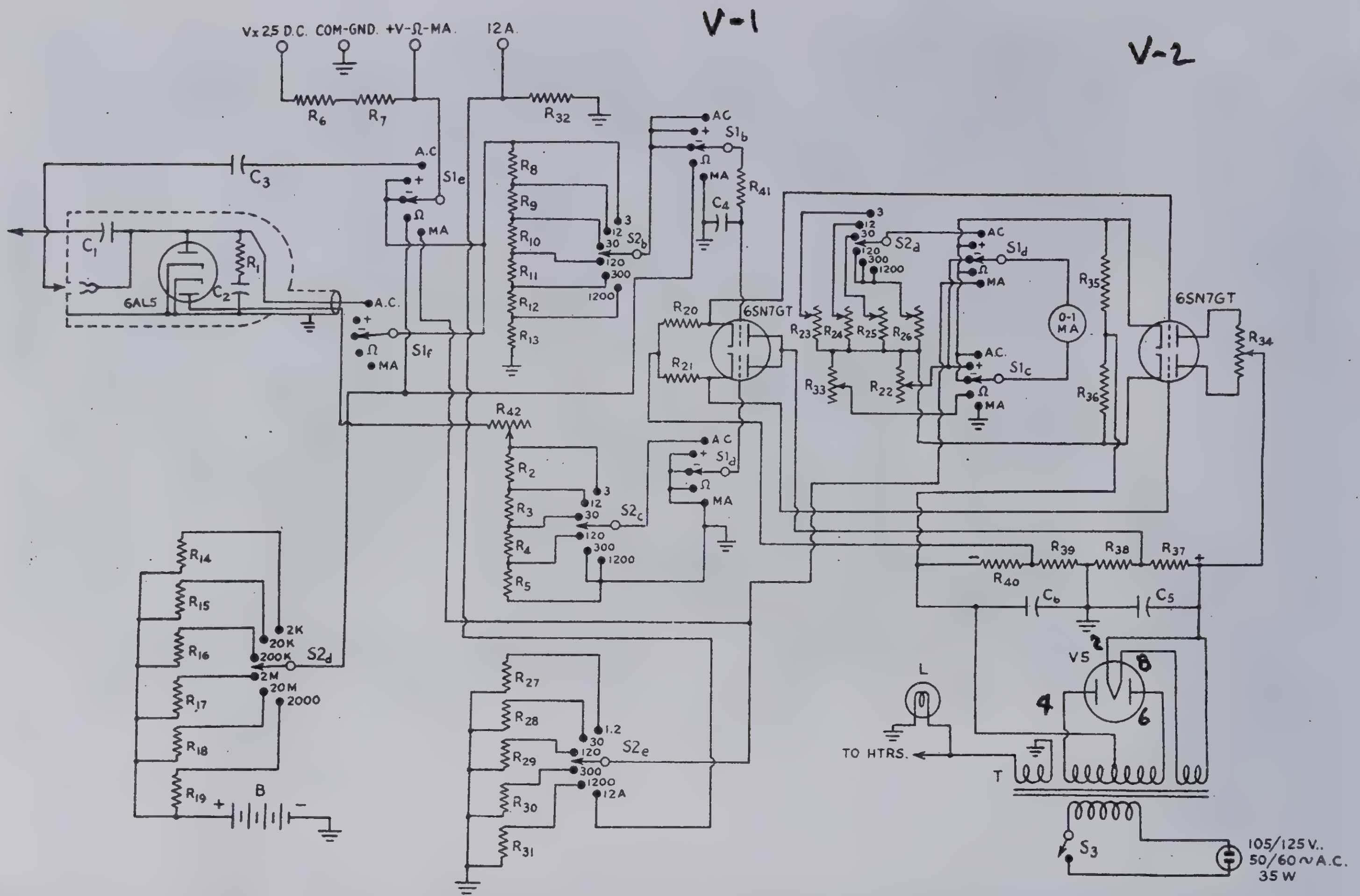


Figure 3

SET resistor for each of these ranges; R23 for 3 volt range, R24 for 12 volt, R25 for 30 volt and R26 for 120 volt range. Adjustment of R26 on the 120 volt range will bring 120, 300 and 1200 volt AC ranges into proper step.

TESTING "VOMAX": The chart appended to Fig. 3 gives voltages correct to 20% which should be observed when the red prod is contacted to the d.c. voltage points listed. Internal a.c. voltages may be similarly measured upon appropriate ranges of "VOMAX" by using both red and black prods to measure mains input voltage, and red prod only for 6.3 volt heater circuits and high voltage power transformer secondaries.

FILTER CAPACITORS: Electrolytic capacitors C5, C6 are polarized. Their + terminals must contact their + spring contactors. Reversal of C5, C6 polarity will ruin them and damage the power transformer and rectifier tube.

CAUTION: HIGH VOLTAGES ARE DEADLY. When measuring high voltages attach black test lead to one side of circuit to be measured, put one hand in pocket, stand on well insulated floor, and holding red test prod lightly between thumb and fore-finger at middle of red prod, contact its tip to high voltage point to be measured. DON'T TAKE CHANCES — YOU HAVE ONLY ONE LIFE — DON'T RISK LOSING IT.

CAUTION: To obtain the extremely useful 1200 volt AC range of "VOMAX" has necessitated operation of the 6AL5 rectifier beyond tube manufacturers' ratings. Extensive tests have revealed no evidence of premature tube deterioration. However, to insure long tube life use the 1200 volt AC range no more than absolutely necessary, and then only briefly. For example, contact prod to source to be measured, read meter, remove prod from source at once.

OPERATING VOLTAGE CHART

Cathode ends of R20, R21 to ground, +2 V d.c.
Cathode ends of R35, R36 to ground, +2 V d.c.
Cathode end of R39 to ground, −17 V d.c.
Cathode end of R40 to ground, −180 V d.c.
Plate end of R38 to ground, +17 V d.c.
Plate end of R37 to ground, +180 V d.c.
Heaters to ground, 6.3 V a.c. (at transformer)
Plates of 5Y3GT to center-tap (tube out of socket) 320 volts a.c.

PARTS LIST

C1 — 0.0005-ufd. silver-mica
C2 — 0.001-ufd. mica
C3 — 0.03-ufd. 3000-volt tubular oil
C4 — 0.005-ufd. mica
C5, C6 — 8-ufd. 350-volt electrolytic
R1 — 20-megohm, ±5 per cent, ¼-watt carbon resistor
R2, R9 — 7.5 megohms, ½ watt metalized resistors*
R3 — 1.5 megohms, ½ watt metalized resistors*
R4, R11 — 750,000 ohms, ½ watt metalized resistors*
R5 — 250,000 ohms ½ watt metalized resistors*
R6, R7, R8 — 37.5 megohms, — watt metalized resistors*
R10 — 3.75 megohms, ½ watt metalized resistors*
R12 — 375,000 ohms, ½ watt metalized resistors*
R13 — 125,000 ohms, ½ watt metalized resistors*
R14 — 10-ohm, 1 per cent ½ watt wire-wound
R15 — 100 ohms, ½ watt metalized resistors*
R16 — 1,000 ohms, ½ watt metalized resistors*
R17 — 10,000 ohms, ½ watt metalized resistors*
R18 — 100,000 ohms, ½ watt metalized resistors*
R19 — 10 megohms, ½ watt metalized resistors*
R20, R21, R41 — 5.1 megohm, ±5 per cent, ½ watt metalized resistor
R22, R23, R24, R25, R26 — 3000 ohm wire-wound potentiometer
R-27 — 258.4 ohm, 1 per cent wire-wound resistor
R28 — 1.758 ohm, 1 per cent wire-wound resistor
R29 — 0.423 ohm, 1 per cent wire wound resistor
R30 — 0.161 ohm, 1 per cent wire-wound resistor
R31 — 0.028 ohm, 1 per cent wire-wound resistor
R32 — Special-Set in test to give 12-ampere range
R33 — 10,000 ohm, wire-wound potentiometer with s.p.s.t. switch
R34 — 3000 ohm wire-wound potentiometer
R35, R36, R37, R40 — 43,000 ohms, ±5 per cent, 2 watt metalized resistors.
R38, R39 — 4,300 ohm, ±5 per cent, ½ watt metalized resistors.
R42 — 10 megohm potentiometer
S1 — 5-position, 6-circuit, 3-section ceramic switch
S2 — 5-circuit, 6-position, 5-section ceramic switch (front section shorting)
T — Power Transformer; 115-volt, 50/60 primary; 5-volts, 2 amp.; 6.3 volts, 1.6 amp.; 640 volts, 50 ma.
*Pairs of I.R.C. BT-½ resistors matched in series to give specified values.

ment preferably includes a tube and coupling transformer, and is most easily made first at one grid, then at the immediately following grid. The gain or loss is the larger voltage observed divided by the smaller.

Because of the inescapable though small input capacitance of any vacuum-tube voltmeter R.F.PROBE, shunting the probe across grid to ground of an r.f. or i.f. stage adds capacity thereto — about 8 mmfd. in the case of "VOMAX" R.F.PROBE contacted directly tip to grid or plate and shell to chassis. This added capacity will slightly detune the circuit being measured and so reduce the voltage appearing across it at the instant of measurement. In preliminary qualitative tests this effect may often be ignored, but for precise measurements the trimmer of the circuit across which voltage is being measured should be adjusted, while the R.F.PROBE is contacted to the circuit, to give maximum voltage reading. The trimmer may be reset by moving the R.F.PROBE along to the next grid circuit and then readjusting the preceding circuit trimmer for greatest voltage reading.

In visual dynamic signal tracing as above the effect of the receivers a.v.c. system must be allowed for. When a strong signal is applied to the antenna input the a.v.c., if functioning properly reduces the gain of each stage enough to hold the i.f. input to the second detector substantially constant. To measure true stage gains the a.v.c. must be rendered inoperative by connecting a jumper from ground to the r.f./i.f. grid side of the first a.v.c. series filter resistor.

From the above it is apparent that a.v.c operation may be accurately checked, and curves plotted if desired, by contacting "VOMAX" R.F.PROBE to the second detector input, retuning the appropriate i.f. trimmer temporarily to give greatest voltage reading, and then reducing antenna input in progressive steps. Plotting a curve of second detector input voltage versus r.f. antenna input voltage gives a basic a.v.c. curve.

In preliminary visual dynamic signal tracing it is convenient to dispense with the necessity of retrimming each circuit measured when the R.F.-PROBE is contacted to it. This is made possible by reducing the 8 mmfd. input capacitance of the R.F.PROBE to some value so low as not to necessitate retrimming. A capacitor of .5 to 1 mmfd. placed in series with the R.F.PROBE tip and the grid or plate to be contacted will reduce R.F.-PROBE capacitance-loading to a value so low as not to significantly upset the tuning of the circuit being measured. Such a capacitance must be as small in physical size as possible. It is most easily obtained by cutting a length of spaghetti insulating tubing of size which will just slip over the R.F.PROBE tip to a length which will completely cover the tip.

This spaghetti sleeve acts as the dielectric of a small capacitor, the plates of which are formed by the R.F.PROBE tip and the socket lug against which the spaghetti (with tip inside it) is contacted. This is a most effective method of simplifying signal tracing. It reduces the sensitivity of the meter considerably, but the 1 volt obtainable from the average local broadcast station or signal generator will usually be sufficient to give a perceptable meter deflection at antenna, first r.f. grid, or certainly at second r.f. grid.

MISCELLANEOUS TESTS

OSCILLATOR VOLTAGE: The strength of oscillation of a superheterodyne or other oscillator may be measured directly in volts with "VOMAX". Contacting the R.F.PROBE to oscillator grid and ground will give a direct indication of the r.f. voltage being developed by the oscillator. It may also be estimated as the negative d.c. voltage developed at the oscillator grid, FUNCTION switch set to DC−, RANGE to appropriate voltage range, and tip in far end of red prod contacted to grid. The first method measures oscillator r.f. voltage directly, the second is indirect and less desirable. By the direct R.F.PROBE method uncertainty is eliminated. Oscillator voltages over each and every band of a receiver up beyond 100 megacycles may be so measured directly.

A.V.C. VOLTAGE: This important class of measurements has been covered under VISUAL DYNAMIC SIGNAL TRACING. A.v.c. voltages are usually negative with respect to chassis ground. FUNCTION knob should therefore be set to DC−, and red prod with tip in far end successively contacted to a.v.c. load resistor, then to each a.v.c.-controlled grid. A stable and reasonably strong input signal should be employed, as from a local broadcast station or signal generator. IT IS CONVENIENT TO CONNECT "VOMAX" ACROSS THE SECOND DETECTOR, OR A.V.C., LOAD RESISTOR IN ALIGNMENT — WHEN ALIGNMENT SHOULD BE EFFECTED TO GIVE GREATEST METER READING.

FM AND A.F.C. DISCRIMINATOR VOLTAGE: The d.c. voltage developed by the discriminator in FM receivers, and in a.f.c. systems, may be measured directly across the discriminator load resistors with "VOMAX". Because this voltage shifts from positive to negative as signal frequency is varied, a zero-center meter is desirable. When properly aligned to a carrier frequency, discriminator output should be zero. Use of a zero-left meter can indicate deviation in only one direction. "VOMAX" can be converted to a zero-center meter for discriminator voltage measurement by simply adjusting the SET V-ZERO knob to bring the meter pointer up to 0 on the db. scale, when deviations in both directions may be readily observed.

TELEVISION RECEIVER VOLTAGE MEASUREMENTS: All types of voltages in television receiver video and audio channels may be measured by "VOMAX". As a peak-reading a.c. voltmeter "VOMAX" is calibrated in R.M.S. values of the sine wave, or .707 of peak value. It may be employed to measure the peak values of sweep oscillator voltages and of saw-tooth or square-wave sources.

AUDIO VOLTAGES: With R.F.PROBE in panel socket, FUNCTION knob at AC and tip in near end of red prod, audio voltages throughout all successive circuits of an audio amplifier may be measured from 20 cycles on up. At high frequencies, and in resistance-capacitance coupled a.f. amplifiers, the effect of the 50 mmfd. input capacitance of "VOMAX" when so used must be allowed for. In making accurate measurements over a wide frequency range it is desirable to do so with the R.F.PROBE directly. However, the 500 mmfd. input capacitor in the R.F.PROBE is so small as to cause error at usual audio frequencies. This may be obviated if one lead from a capacitor of .025 to .1 mfd. is temporarily soldered to the small screw-head found on the R.F.PROBE ceramic head and the other lead of this capacitor used as the probe tip to the circuit under measurement.

SUPERIMPOSED VOLTAGES: D.C. voltages present in a circuit simultaneously with a.c. voltages, and vice versa, can be independently measured by "VOMAX" with no special precautions. When using a.c. functions the series input capacitor blocks out d.c. When using d.c. functions, the a.c. filter R41, C4 filters out a.c.

INSULATION RESISTANCE: Measurement of insulation resistance of capacitors, transformers, reactors and other insulators has been covered under INSULATION RESISTANCE MEASUREMENTS.

PRECAUTIONS: In order to keep input capacitance to a minimum in AC voltage functions of "VOMAX", and to similarly hold down input capacitance in DC operation, the red test lead has not been shielded. In making measurements on high resistance circuits, therefore, the red test lead should be kept away from a.c. mains conduits or wiring. In AC operation, grasp the red prod at its far end, vice versa in DC. Keep the red lead away from the body. Observation of these precautions, coupled with possible grounding of "VOMAX" panel in extreme cases of local electrostatic fields, will avoid errors due to same while keeping meter capacitance at a minimum.

CAPACITANCE MEASUREMENTS: Accurate capacitance measurement is possible only with a bridge circuit which takes into account both capacitance and resistance, which has a dissipation factor or power factor balance. The same is true for inductance measurements. However, rough but useful capacitance measurements may be made in an emergency with "VOMAX". What is so measured is the capacitance reactance, Cx, of the capacitor under test. The method involves connecting the unknown capacitor and a variable resistor in series across a source of 5 to 120 volts of 60 cycle a.c., and adjusting the resistor until the voltage measured across it equals exactly the voltage measured across the capacitor. The resistor is then measured upon the OHMMETER of "VOMAX" and its value located upon Fig. 4, from which point the capacitance may be read directly. One 3000 ohm rheostat and one 3 megohm rheostat will serve for capacitors between 10 and .01 mfd. (When using 50 cycles, true capacitance is ⅚ of the value so indicated.)

MAINTENANCE

Built of the highest quality parts to close to military standards of excellence, no trouble need be anticipated with "VOMAX" over long periods of time. Accuracy will be well maintained even though the same tubes are used in continuous operation for long periods of time. Variation in and aging of tube characteristics have little effect upon operation.

OHMMETER BATTERIES: Ohmmeter batteries should be replaced when they measure less than 2.2 volts total as measured by +DC FUNCTION, 3V RANGE of "VOMAX" itself or when OHMMETER readings become unstable. Connections to batteries should be unsoldered, old batteries removed, new ones inserted and connections thereto resoldered.

VACUUM TUBES: 6SN7GT Vacuum tubes may be replaced when SET V-ZERO knob will not bring meter pointer to zero, or when zero appears unstable even after 10 to 15 minutes warm-up time. Known-good tubes may be directly substituted for original tubes. The same applies to the 6AL5 R.F.PROBE tube. It should be replaced when no adjustment of R42 only will make AC zero coincident with DC zero. If the first replacement 6AL5 tried will not permit establishing AC zero coincident with DC zero through adjustment of R42 alone, a second tube should be tried. If no second tube is available, required coincidence of AC and DC zeros brought about through adjustment of R42 only may be obtained by interchanging the connections to lugs 2 and 7 at the R.F.-PROBE tube socket.

CALIBRATION: Recalibration should practically never be necessary unless the instrument is abused, damaged or its internal RANGE SET resistor adjustments are tampered with. DC calibration may be affected by applying 2 or 3 volts of precisely known d.c. voltage (measured by an external precision laboratory-type meter standard) to the 3V, +DC range of "VOMAX" and then carefully adjusting R22 for identical readings between the external standard meter and "VOMAX" meter. Higher voltage ranges when tested will then be found to be in step.

AC calibration requires an equally good meter having ranges of 2/3, 8/12, 20/30 and 80/120 volts, together with a low-frequency a.c. voltage source within these limits. Having zeroed "VOMAX", calibration consists of applying a definitely known 50 or 60 cycle a.c. voltage to "VOMAX" input, and adjustment of internal a.c. RANGE SET resistors to identicality of meter readings for the four different a.c. voltages on the four meter ranges. Using an external voltage which will give a meter reading somewhere upon the upper ⅓rd of "VOMAX" scale for each of the 3, 12, 30 and 120 volt ranges, adjust the appropriate RANGE

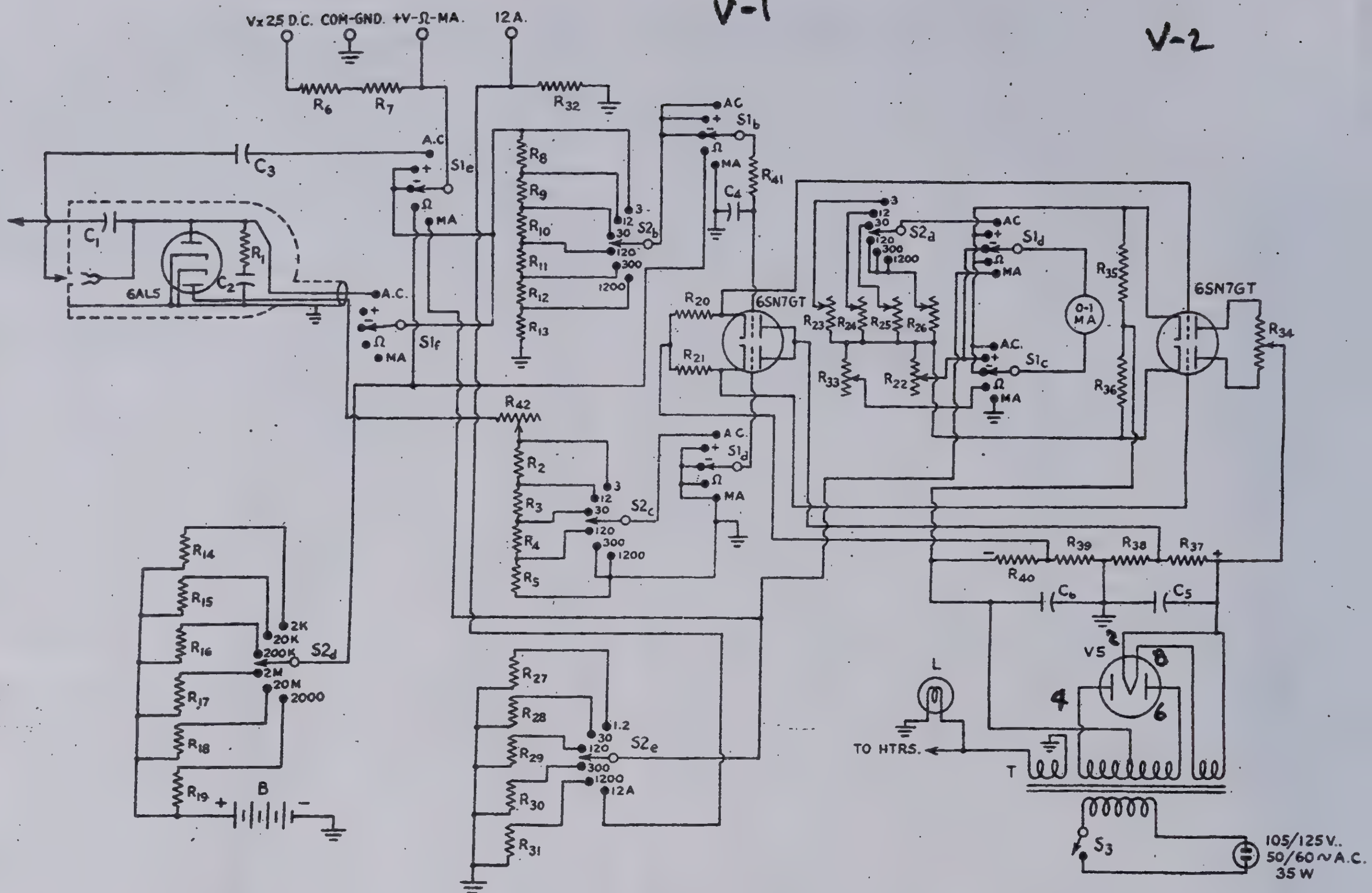


Figure 3

SET resistor for each of these ranges; R23 for 3 volt range, R24 for 12 volt, R25 for 30 volt and R26 for 120 volt range. Adjustment of R26 on the 120 volt range will bring 120, 300 and 1200 volt AC ranges into proper step.

TESTING "VOMAX": The chart appended to Fig. 3 gives voltages correct to 20% which should be observed when the red prod is contacted to the d.c. voltage points listed. Internal a.c. voltages may be similarly measured upon appropriate ranges of "VOMAX" by using both red and black prods to measure mains input voltage, and red prod only for 6.3 volt heater circuits and high voltage power transformer secondaries.
FILTER CAPACITORS: Electrolytic capacitors C5, C6 are polarized. Their + terminals must contact their + spring contactors. Reversal of C5, C6 polarity will ruin them and damage the power transformer and rectifier tube.

CAUTION: HIGH VOLTAGES ARE DEADLY. When measuring high voltages attach black test lead to one side of circuit to be measured, put one hand in pocket, stand on well insulated floor, and holding red test prod lightly between thumb and fore-finger at middle of red prod, contact its tip to high voltage point to be measured. DON'T TAKE CHANCES — YOU HAVE ONLY ONE LIFE — DON'T RISK LOSING IT.

CAUTION: To obtain the extremely useful 1200 volt AC range of "VOMAX" has necessitated operation of the 6AL5 rectifier beyond tube manufacturers' ratings. Extensive tests have revealed no evidence of premature tube deterioration. However, to insure long tube life use the 1200 volt AC range no more than absolutely necessary, and then only briefly. For example, contact prod to source to be measured, read meter, remove prod from source at once.

OPERATING VOLTAGE CHART

Cathode ends of R20, R21 to ground, +2 V d.c.
Cathode ends of R35, R36 to ground, +2 V d.c.
Cathode end of R39 to ground, −17 V d.c.
Cathode end of R40 to ground, −180 V d.c.
Plate end of R38 to ground, +17 V d.c.
Plate end of R37 to ground, +180 V d.c.
Heaters to ground, 6.3 V a.c. (at transformer)
Plates of 5Y3GT to center-tap (tube out of socket) 320 volts a.c.

PARTS LIST

C1 — 0.0005-ufd. silver-mica
C2 — 0.001-ufd. mica
C3 — 0.03-ufd. 3000-volt tubular oil
C4 — 0.005-ufd. mica
C5, C6 — 8-ufd. 350-volt electrolytic
R1 — 20-megohm, ±5 per cent, ¼-watt carbon resistor
R2, R9 — 7.5 megohms, ½ watt metalized resistors*
R3 — 1.5 megohms, ½ watt metalized resistors*
R4, R11 — 750,000 ohms, ½ watt metalized resistors*
R5 — 250,000 ohms ½ watt metalized resistors*
R6, R7, R8 — 37.5 megohms, — watt metalized resistors*
R10 — 3.75 megohms, ½ watt metalized resistors*
R12 — 375,000 ohms, ½ watt metalized resistors*
R13 — 125,000 ohms, ½ watt metalized resistors*
R14 — 10-ohm, 1 per cent ½ watt wire-wound
R15 — 100 ohms, ½ watt metalized resistors*
R16 — 1,000 ohms, ½ watt metalized resistors*
R17 — 10,000 ohms, ½ watt metalized resistors*
R18 — 100,000 ohms, ½ watt metalized resistors*
R19 — 10 megohms, ½ watt metalized resistors*
R20, R21, R41 — 5.1 megohm, ±5 per cent, ½ watt metalized resistor
R22, R23, R24, R25, R26 — 3000 ohm wire-wound potentiometer
R-27 — 258.4 ohm, 1 per cent wire-wound resistor
R28 — 1.758 ohm, 1 per cent wire-wound resistor
R29 — 0.423 ohm, 1 per cent wire wound resistor
R30 — 0.161 ohm, 1 per cent wire-wound resistor
R31 — 0.028 ohm, 1 per cent wire-wound resistor
R32 — Special-Set in test to give 12-ampere range
R33 — 10,000 ohm, wire-wound potentiometer with s.p.s.t. switch
R34 — 3000 ohm wire-wound potentiometer
R35, R36, R37, R40 — 43,000 ohms, ±5 per cent, 2 watt metalized resistors.
R38, R39 — 4,300 ohm, ±5 per cent, ½ watt metalized resistors.
R42 — 10 megohm potentiometer
S1 — 5-position, 6-circuit, 3-section ceramic switch
S2 — 5-circuit, 6-position, 5-section ceramic switch (front section shorting)
T — Power Transformer; 115-volt, 50/60 primary; 5-volts, 2 amp.; 6.3 volts, 1.6 amp.; 640 volts, 50 ma.
*Pairs of I.R.C. BT-½ resistors matched in series to give specified values.

2
5
1
4
3
6
7
8

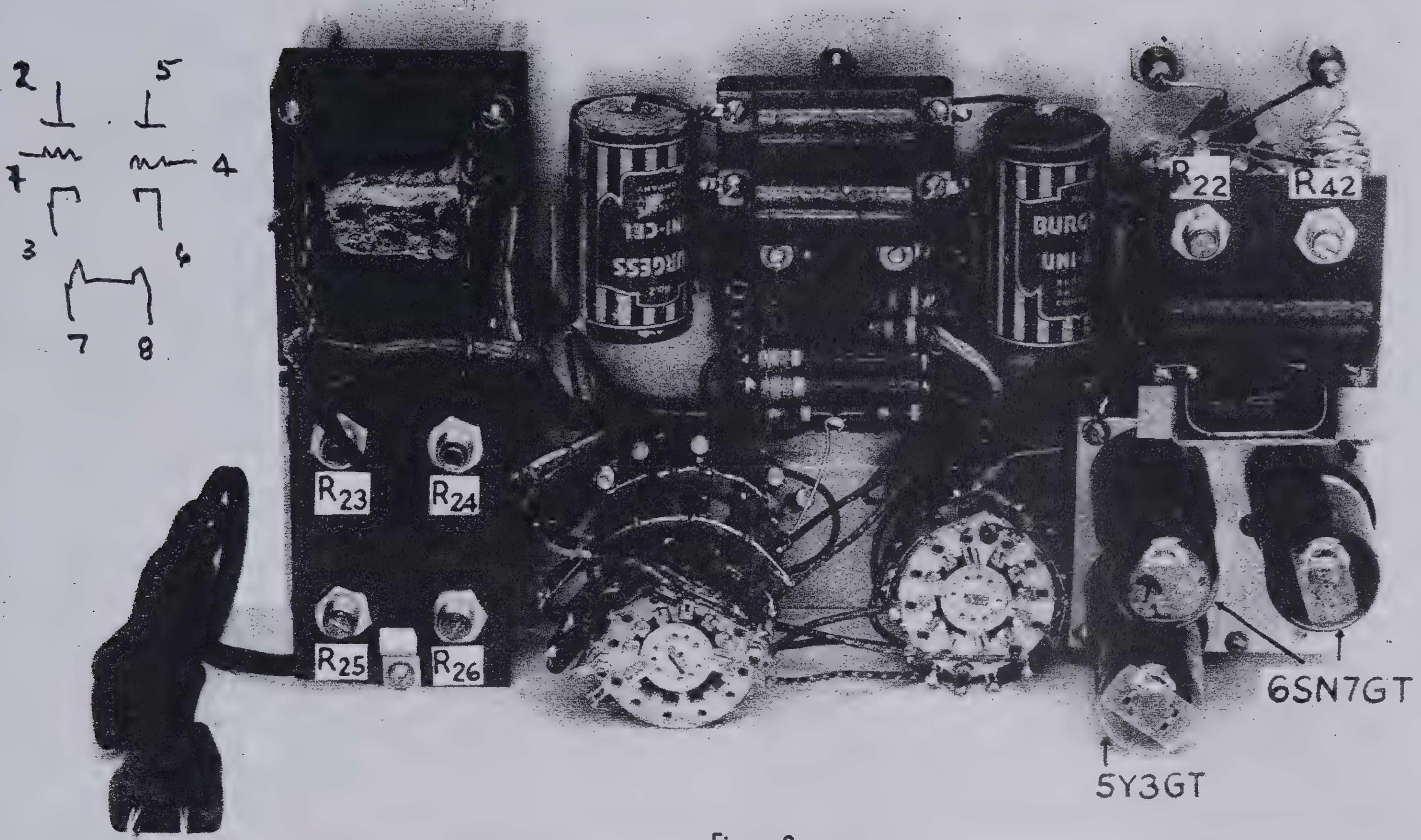
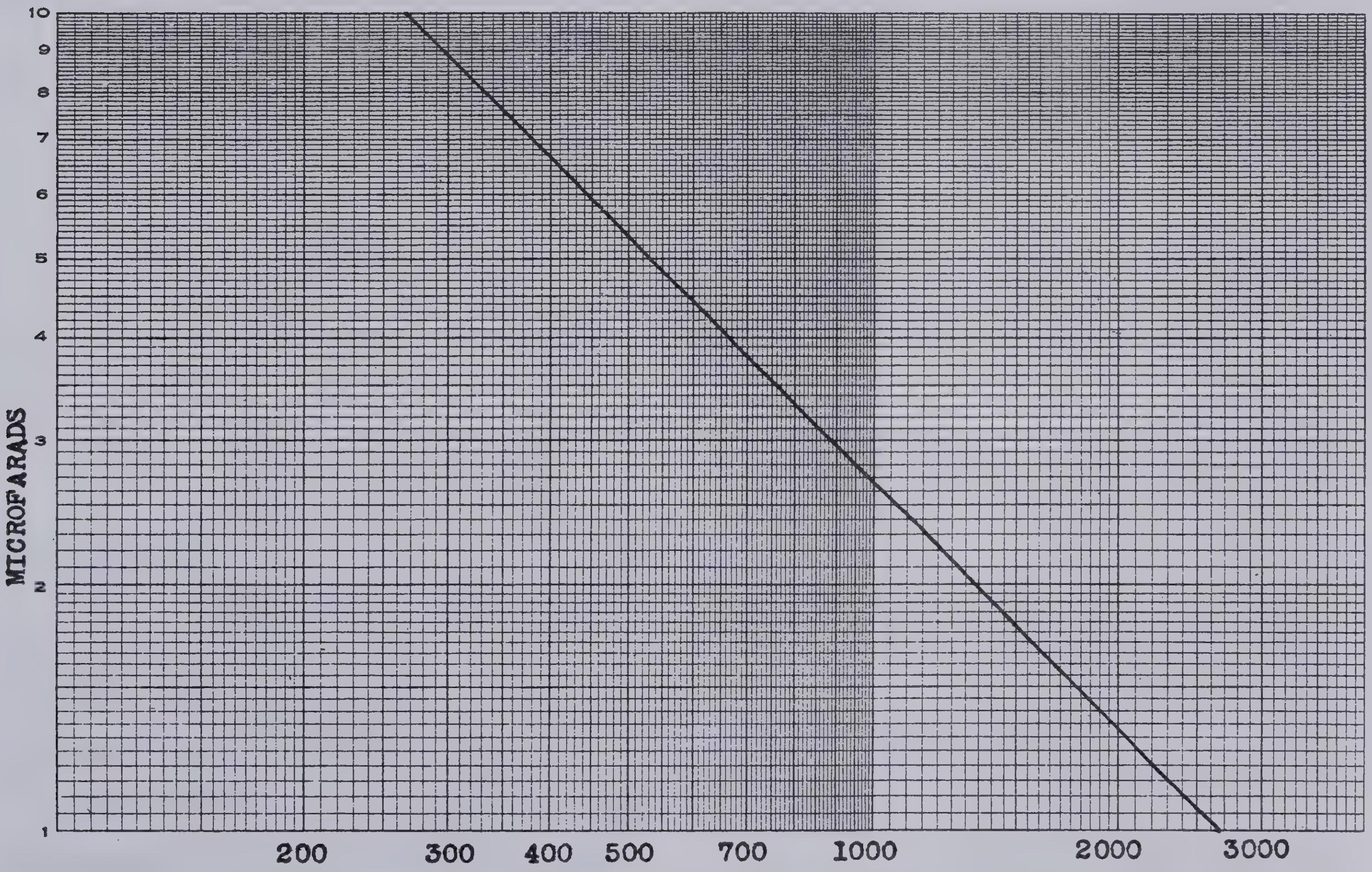
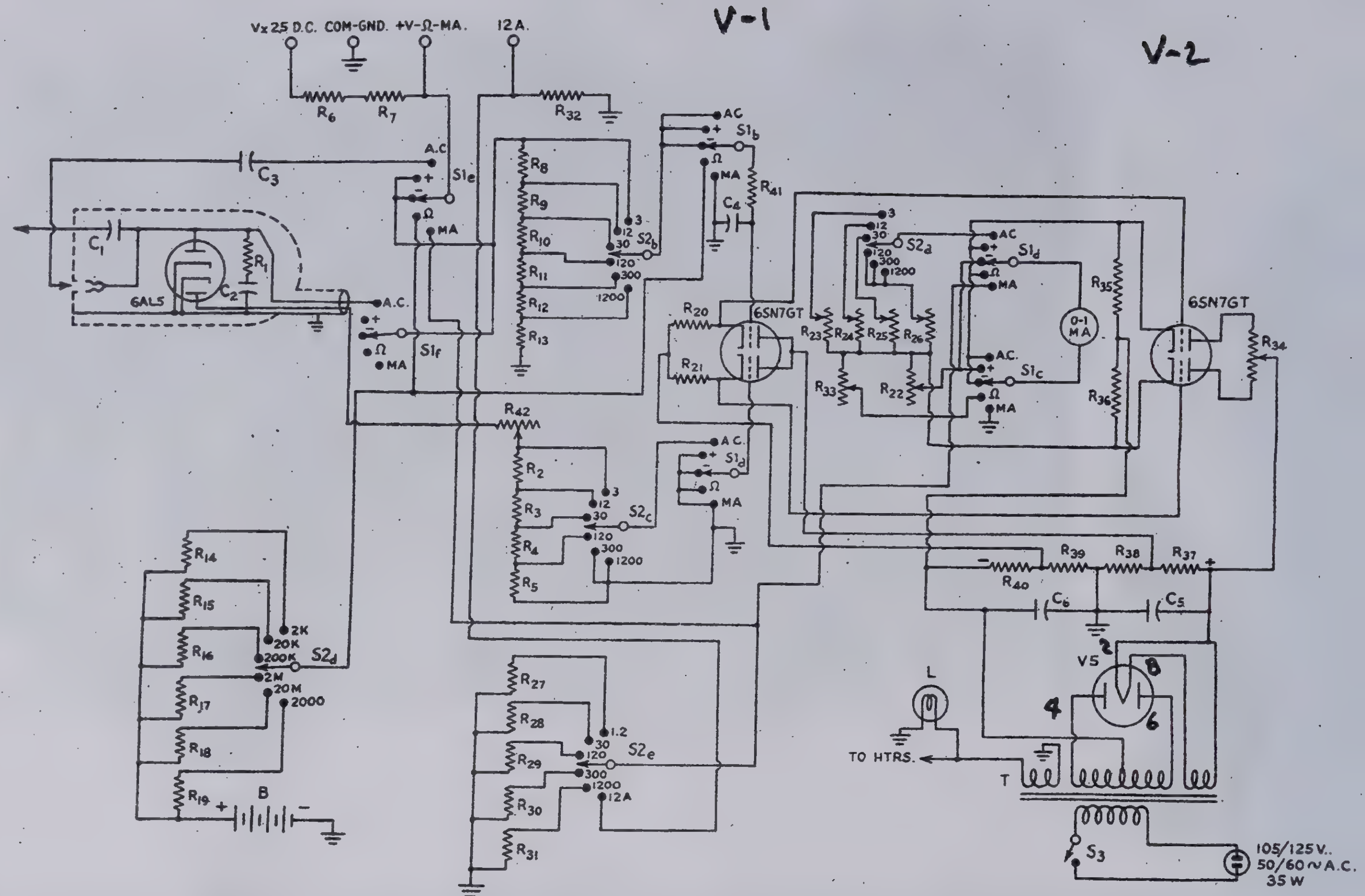

BURGESS
UNI-CEL
R22
R42
R23
R24
R25
R26
6SN7GT
5Y3GT

Figure 2



FOR EACH ZERO ADDED TO RESISTANCE (BOTTOM SCALE) ADD ONE
DECIMAL POINT IN FRONT OF MICROFARADS

FIGURE 4



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R13 — 125,000 ohms, ½ watt metalized resistors*
R14 — 10-ohm, 1 per cent ½ watt wire-wound
R15 — 100 ohms, ½ watt metalized resistors*
R16 — 1,000 ohms, ½ watt metalized resistors*
R17 — 10,000 ohms, ½ watt metalized resistors*
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*Pairs of I.R.C. BT-½ resistors matched in series to give specified values.

GENERAL

Model 900 "VOMAX" is a true vacuum-tube voltmeter of new and markedly advanced design. It makes possible d.c. voltage measurement at such astronomically high input resistances as to substantially eliminate loading effects upon sensitive circuits. It provides for a.c. voltage measurements at extraordinarily high meter input resistance throughout the frequency range of 20 cycles to above 100 megacycles. Vacuum-tube resistance ranges cover .2 ohms through 2,000 megohms, while insulation resistance well beyond this range may be measured with the addition of an external battery. Direct currents from 50 microamperes through 12 amperes may be measured. Decibel ranges are from −10 through +50 db. Capacitances over a wide range of commercial values may be measured by the addition of two external rheostats and reference to a chart.

Through new war-born inventions the effects of fluctuations in mains input voltage and of aging of vacuum tubes are practically completely eliminated. The usual deleterious effects of vacuum-tube grid and gas currents heretofore so ruinous of accuracy have been practically eliminated through design features exclusive to "VOMAX".

One knob adjustment sets meter zero for all ranges at start of operation. A second knob establishes full scale ohmmeter set, when resistance ranges may be shifted without requiring re-zeroing.

The name "VOMAX" is basically descriptive of functions — "V" for volts, "O" for ohms, "MA" for milliamperes/amperes, and "X" for capacitative reactance, decibels, a.f. and r.f. volts and visual dynamic signal tracing. No such short title can be adequately descriptive of the multitude of ranges and functions which "VOMAX" makes available to the research engineer and serious service technician, not to mention its unusually high accuracy. Stability rivals that of the basic meter movement itself.

ELECTRICAL SPECIFICATIONS

INPUT: 105/125 volts, 50/60 cycles alternating current only. ("VOMAX" may be adapted to higher mains voltages, of frequency between 50 and 60 cycles **only** by a conventional reducing transformer, or by insertion of a series input resistance — 30 watts per 100 volts — in mains cord having total resistance determined upon the basis of 3.46 ohms per volt of increased mains voltage above nominal "VOMAX" input of 115 volts.)

RANGES: Fifty-one effective ranges divided as follows:

D.C. volts 3, 12, 30, 120, 300 and 1200 at 51 megohms constant input resistance (1 megohm in capacity-isolating test prod). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.

D.C. volts 7.5, 30, 75, 300, 750 and 3000 at 126 megohms constant input resistance (obtained at Vx2.5 and COM-GND jacks). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.

A.C. volts 3, 12, 30, 120, 300 and 1200 volts at circuit loading equivalent to 6.6 megohms shunted by 50 mmfd. (diode probe plugged into panel socket). Accuracy ±5%.

R.F. volts same as A.C. volts but at circuit loading equivalent to 6.6 megohms shunted by 8 mmfd. (diode probe withdrawn for direct contacting to circuit to be measured). Accuracy ±5%.

OHMS: Six resistance ranges, all zero-left, of 2,000, 20,000, 200,000 ohms and 2, 20 and 2,000 megohms. Accuracy ±2% of full scale, ±1% of indicated resistance.

DECIBELS: Three db. ranges (0 db. =1 milliwatt in 600 ohms) of −10/+10, +10/+30 and +30/+50 db.

CURRENT: Six direct current ranges of 1.2, 30, 120, 300 and 1200 milliamperes and 12 amperes. Accuracy ±3%.

FREQUENCY RANGE: 20 cycles through 100 megacycles. "VOMAX" may be employed up to several hundred megacycles with lesser accuracy due to progressively increasing errors occasioned by resonance and transit-time effects in diode rectifier probe.

METER: 4⅝" D'Arsonval movement, 0-1 ma. full scale. Accuracy ±2% of full scale.

MULTIPLIERS/SHUNTS; Multiplier resistors are ±1% matched pairs aged for stability. Current shunts are ±1% wire-wound resistors.

CAPACITORS: Capacitors are hermetically sealed molded-mica, and oil impregnated and electrolytic units hermetically sealed in metal cases. Electrolytic units, though of standard easily replaceable commercial type, are plug-in through employment of new spring contact clips.

ACCESSORIES: Two Burgess No. 2 1½-volt flashlight batteries for ohmmeter circuit.

One tube complement consisting of 1 — 6AL5 miniature dual diode, 2 — 6SN7GT dual triode cathode follower and meter-actuating tubes, 1 — 5Y3GT (or 5Z4) rectifier.

One red and one black test prods with 48" leads (red prod with reversible tip for a.c. and d.c. voltage measurements).

OVERLOAD PROTECTION: Meter protected against burn-out due to overload on volts, ohms, db., but not on ma/a.

NEW CIRCUIT

The extraordinary stability and dependability of "VOMAX" are due to entirely new and war-born engineering advances. The circuit diagram of Fig. 3 will upon careful study reveal these advanced design features and differences from conventional instruments.

The high order of stability, independence of mains voltage fluctuations and aging of vacuum tubes are obtained by full-balanced circuits in which possible variations in each tube circuit are balanced out by equal and opposite variations in complementary balancing tubes (second sections of each dual tube). Unusually heavy degeneration in each triode circuit, coupled with high diode load resistance, operate to almost completely wash out variations due to voltage fluctuations and tube aging.

The sections of the 6AL5 and 6SN7GT tubes at the top of Fig. 3 comprise the "signal" or measurement circuit. The duplicate sections of these tubes toward the bottom of the diagram constitute the balancing circuits. Each measurement tube is seen to have its companion balancing tube. Three dual-purpose tubes are employed in preference to six single-purpose tubes, since manufactured and processed identically the uniformity between sections of the same tube may be anticipated to be greater over time than can be expected of separate tubes which might be manufactured under markedly different circumstances.

The upper section of the 6AL5 functions as the diode rectifier for a.c. and r.f. voltage measurements, being switched into circuit when so required by ganged switches S1e and S1f. Any diode generates within itself "contact potential" which will produce an initial voltmeter reading. This contact potential is balanced out by that similarly generated within the second diode of the 6AL5 to yield an initial voltmeter zero. Exactly as the contact potential of the upper measurement diode (as well as the rectified a.c. employed to actuate the d.c. voltmeter) is divided down by voltmeter range "stick" R8 through R13 and RANGE switch S2b, so is the balancing potential controlled in step therewith by R2 through R5 and RANGE switch S2c. Initial balance between measurement and balancing contact potentials is established by factory adjustment of R42.

The central 6SN7GT dual triode in Fig. 2 is the cathode follower measurement and balancing tube combination. Operated Class A at very low plate voltage and with extraordinarily heavy degeneration, it explains the unusual freedom of "VOMAX" from usual grid and gas current effects. Its plate voltage is so low as to prevent ionization of residual gas or the appearance of grid current. This is its exclusive and vitally important function. Input voltages are fed to its upper grid through RANGE "stick" R8 through R13 and switches S2B and S1B. In a.c. operation balancing contact potential is fed to its lower grid, which is grounded for all other functions, by switch S1a.

The right hand 6SN7GT tube in Fig. 3 is the meter-actuating triode; top section for measurement, bottom section for balancing. Switches S1c and S1d reverse the meter polarity as required for a.c., d.c.+, and d.c.− measurements, and shift the meter alone over to direct current shunts R27 through R32 and RANGE switch S2e. R34 is the front panel SET-V-ZERO knob, one single adjustment of which sets meter zero for all functions.

Ohmmeter operation involves use of the d.c. vacuum-tube voltmeter comprised by the two 6SN7GT tubes and their associated components switched over to 3-volt dry battery B, ohms RANGE switch S2d and ohms multiplier resistors R14 through R19.

The d.c. voltmeter employed for all voltage and ohms measurements (the two 6SN7GT tubes and associated components) has a basic range of 0-3 volts, which is multiplied to yield higher ranges by 50 megohm "stick" R8 through R13. For the Vx2.5 ranges, 75 megohms (R6, R7) is placed in series with this "stick" and the Vx2.5 panel jack. Switch S2a selects the appropriate factory adjusted wire-wound RANGE SET resistors; R22 for d.c., R23, R24, R25 and R26 for a.c.; and panel ADJ Ω control R33 for setting meter initially to full scale in resistance measurements.

Transformer T and 5Y3GT power supply rectifier develop approximately 360 volts across voltage divider-bleeder R37, R38, R39 and R40, with required filtration accomplished by plug-in capacitors C5 and C6. Half of this voltage is effectively across plate-to-cathode of the right-hand 6SN7GT, approximately 10% thereof on the center cathode follower 6SN7GT. Substantially equal negative voltages developed across R39, R40 operate to offset the large voltage drops across degenerative cathode resistors. R35, R36 and R20, R21 to insure Class A operation of these tubes.

One of the particular advantages of "VOMAX" is that, used as an a.c. or d.c. voltmeter, it can measure its own internal operating voltages. Used as an ohmmeter it can measure its own internal multiplier resistors. It is thus practically self-servicing.

PANEL CONTROLS

The panel nomenclature of "VOMAX" is so self-explanatory as to

GENERAL

Model 900 "VOMAX" is a true vacuum-tube voltmeter of new and markedly advanced design. It makes possible d.c. voltage measurement at such astronomically high input resistances as to substantially eliminate loading effects upon sensitive circuits. It provides for a.c. voltage measurements at extraordinarily high meter input resistance throughout the frequency range of 20 cycles to above 100 megacycles. Vacuum-tube resistance ranges cover .2 ohms through 2,000 megohms, while insulation resistance well beyond this range may be measured with the addition of an external battery. Direct currents from 50 microamperes through 12 amperes may be measured. Decibel ranges are from −10 through +50 db. Capacitances over a wide range of commercial values may be measured by the addition of two external rheostats and reference to a chart.

Through new war-born inventions the effects of fluctuations in mains input voltage and of aging of vacuum tubes are practically completely eliminated. The usual deleterious effects of vacuum-tube grid and gas currents heretofore so ruinous of accuracy have been practically eliminated through design features exclusive to "VOMAX".

One knob adjustment sets meter zero for all ranges at start of operation. A second knob establishes full scale ohmmeter set, when resistance ranges may be shifted without requiring re-zeroing.

The name "VOMAX" is basically descriptive of functions — "V" for volts, "O" for ohms, "MA" for milliamperes/amperes, and "X" for capacitative reactance, decibels, a.f. and r.f. volts and visual dynamic signal tracing. No such short title can be adequately descriptive of the multitude of ranges and functions which "VOMAX" makes available to the research engineer and serious service technician, not to mention its unusually high accuracy. Stability rivals that of the basic meter movement itself.

ELECTRICAL SPECIFICATIONS

INPUT: 105/125 volts, 50/60 cycles alternating current only. ("VOMAX" may be adapted to higher mains voltages, of frequency between 50 and 60 cycles **only** by a conventional reducing transformer, or by insertion of a series input resistance — 30 watts per 100 volts — in mains cord having total resistance determined upon the basis of 3.46 ohms per volt of increased mains voltage above nominal "VOMAX" input of 115 volts.)

RANGES: Fifty-one effective ranges divided as follows:

D.C. volts 3, 12, 30, 120, 300 and 1200 at 51 megohms constant input resistance (1 megohm in capacity-isolating test prod). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.

D.C. volts 7.5, 30, 75, 300, 750 and 3000 at 126 megohms constant input resistance (obtained at Vx2.5 and COM-GND jacks). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.

A.C. volts 3, 12, 30, 120, 300 and 1200 volts at circuit loading equivalent to 6.6 megohms shunted by 50 mmfd. (diode probe plugged into panel socket). Accuracy ±5%.

R.F. volts same as A.C. volts but at circuit loading equivalent to 6.6 megohms shunted by 8 mmfd. (diode probe withdrawn for direct contacting to circuit to be measured). Accuracy ±5%.

OHMS: Six resistance ranges, all zero-left, of 2,000, 20,000, 200,000 ohms and 2, 20 and 2,000 megohms. Accuracy ±2% of full scale, ±1% of indicated resistance.

DECIBELS: Three db. ranges (0 db. =1 milliwatt in 600 ohms) of −10/+10, +10/+30 and +30/+50 db.

CURRENT: Six direct current ranges of 1.2, 30, 120, 300 and 1200 milliamperes and 12 amperes. Accuracy ±3%.

FREQUENCY RANGE: 20 cycles through 100 megacycles. "VOMAX" may be employed up to several hundred megacycles with lesser accuracy due to progressively increasing errors occasioned by resonance and transit-time effects in diode rectifier probe.

METER: 4⅝" D'Arsonval movement, 0-1 ma. full scale. Accuracy ±2% of full scale.

MULTIPLIERS/SHUNTS: Multiplier resistors are ±1% matched pairs aged for stability. Current shunts are ±1% wire-wound resistors.

CAPACITORS: Capacitors are hermetically sealed molded-mica, and oil impregnated and electrolytic units hermetically sealed in metal cases. Electrolytic units, though of standard easily replaceable commercial type, are plug-in through employment of new spring contact clips.

ACCESSORIES: Two Burgess No. 2 1½-volt flashlight batteries for ohmmeter circuit.

One tube complement consisting of 1 — 6AL5 miniature dual diode, 2 — 6SN7GT dual triode cathode follower and meter-actuating tubes, 1 — 5Y3GT (or 5Z4) rectifier.

One red and one black test prods with 48" leads (red prod with reversible tip for a.c. and d.c. voltage measurements).

OVERLOAD PROTECTION: Meter protected against burn-out due to overload on volts, ohms, db., but not on ma/a.

NEW CIRCUIT

The extraordinary stability and dependability of "VOMAX" are due to entirely new and war-born engineering advances. The circuit diagram of Fig. 3 will upon careful study reveal these advanced design features and differences from conventional instruments.

The high order of stability, independence of mains voltage fluctuations and aging of vacuum tubes are obtained by full-balanced circuits in which possible variations in each tube circuit are balanced out by equal and opposite variations in complementary balancing tubes (second sections of each dual tube). Unusually heavy degeneration in each triode circuit, coupled with high diode load resistance, operate to almost completely wash out variations due to voltage fluctuations and tube aging.

The sections of the 6AL5 and 6SN7GT tubes at the top of Fig. 3 comprise the "signal" or measurement circuit. The duplicate sections of these tubes toward the bottom of the diagram constitute the balancing circuits. Each measurement tube is seen to have its companion balancing tube. Three dual-purpose tubes are employed in preference to six single-purpose tubes, since manufactured and processed identically the uniformity between sections of the same tube may be anticipated to be greater over time than can be expected of separate tubes which might be manufactured under markedly different circumstances.

The upper section of the 6AL5 functions as the diode rectifier for a.c. and r.f. voltage measurements, being switched into circuit when so required by ganged switches S1e and S1f. Any diode generates within itself "contact potential" which will produce an initial voltmeter reading. This contact potential is balanced out by that similarly generated within the second diode of the 6AL5 to yield an initial voltmeter zero. Exactly as the contact potential of the upper measurement diode (as well as the rectified a.c. employed to actuate the d.c. voltmeter) is divided down by voltmeter range "stick" R8 through R13 and RANGE switch S2b, so is the balancing potential controlled in step therewith by R2 through R5 and RANGE switch S2c. Initial balance between measurement and balancing contact potentials is established by factory adjustment of R42.

The central 6SN7GT dual triode in Fig. 2 is the cathode follower measurement and balancing tube combination. Operated Class A at very low plate voltage and with extraordinarily heavy degeneration, it explains the unusual freedom of "VOMAX" from usual grid and gas current effects. Its plate voltage is so low as to prevent ionization of residual gas or the appearance of grid current. This is its exclusive and vitally important function. Input voltages are fed to its upper grid through RANGE "stick" R8 through R13 and switches S2B and S1B. In a.c. operation balancing contact potential is fed to its lower grid, which is grounded for all other functions, by switch S1a.

The right hand 6SN7GT tube in Fig. 3 is the meter-actuating triode; top section for measurement, bottom section for balancing. Switches S1c and S1d reverse the meter polarity as required for a.c., d.c.+, and d.c.− measurements, and shift the meter alone over to direct current shunts R27 through R32 and RANGE switch S2e. R34 is the front panel SET-V-ZERO knob, one single adjustment of which sets meter zero for all functions.

Ohmmeter operation involves use of the d.c. vacuum-tube voltmeter comprised by the two 6SN7GT tubes and their associated components switched over to 3-volt dry battery B, ohms RANGE switch S2d and ohms multiplier resistors R14 through R19.

The d.c. voltmeter employed for all voltage and ohms measurements (the two 6SN7GT tubes and associated components) has a basic range of 0-3 volts, which is multiplied to yield higher ranges by 50 megohm "stick" R8 through R13. For the Vx2.5 ranges, 75 megohms (R6, R7) is placed in series with this "stick" and the Vx2.5 panel jack. Switch S2a selects the appropriate factory adjusted wire-wound RANGE SET resistors; R22 for d.c., R23, R24, R25 and R26 for a.c.; and panel ADJ Ω control R33 for setting meter initially to full scale in resistance measurements.

Transformer T and 5Y3GT power supply rectifier develop approximately 360 volts across voltage divider-bleeder R37, R38, R39 and R40, with required filtration accomplished by plug-in capacitors C5 and C6. Half of this voltage is effectively across plate-to-cathode of the right-hand 6SN7GT, approximately 10% thereof on the center cathode follower 6SN7GT. Substantially equal negative voltages developed across R39, R40 operate to offset the large voltage drops across degenerative cathode resistors. R35, R36 and R20, R21 to insure Class A operation of these tubes.

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PANEL CONTROLS

The panel nomenclature of "VOMAX" is so self-explanatory as to

enable the veriest tyro to operate the instrument in practically all routine measurements. A complete understanding of all controls and functions will insure greatest satisfaction, however.

FUNCTION knob (switches S1a through S1f) has five positions. Its setting determines the type of measurements to be made. AC position is for a.c., r.f. and d.b. measurements. The COM-GND jack is **always** connected through the black test prod to the chassis or common ground of the equipment under test. With FUNCTION knob in +DC position "VOMAX" will measure selected d.c. voltages upon application of the tip screwed into the far end of the red test prod to any point of voltage positive with respect to chassis of equipment under test. FUNCTION knob in DC— position will measure the same range of d.c. voltages, but negative with respect to equipment chassis. FUNCTION knob thus reverses d.c. polarity when required and makes unnecessary reversal of test leads. Ω position of FUNCTION knob provides for resistance measurements; MA position provides for direct current measurements.

RANGE KNOB (switches S2a through S2e) selects the desired voltage, resistance or current range. Its six positions are so clearly identified as to require little comment. It is merely necessary to set RANGE knob to the position providing the full-scale meter range desired for any particular type of measurement.

PANEL JACKS

Two of the four jacks at the upper left of the panel provide additional ranges when correctly utilized. The COM-GND jack is common to all except r.f. measurements (r.f. probe withdrawn from instrument). It is grounded to "VOMAX" panel and circuit. By means of the black test lead it should be connected to the chassis or common grounded circuit of equipment under test. The red test prod with its small cord tip inserted into the +V — Ω —MA jack provides the remaining meter connection to the circuit being tested.

The 12 ampere direct current range is obtained between the COM-GND (negative) and 12A (positive) jacks.

The six positive and six negative (polarity determined by FUNCTION switch position) d.c. voltage ranges of 7.5, 30, 75, 300, 750 and 3000 volts are obtained between COM-GND (negative) and Vx2.5 (positive) jacks.

READING METER

The top scale is graduated directly in ohms from 0 to 2,000. The six RANGE knob positions yield six different resistance ranges differing only in the number of zeros to be added to the scale figures, the full-scale reading in each case being directly indicated by the RANGE knob figures.

The 3-volt a.c. range only is read on the scale immediately below the ohms figures.

All other voltage ranges, and direct current as well, are read on the green center scales. The graduations upon upper and lower green scales are identically spaced, the scales being linear. All voltage ranges beginning with the figure "3" are read upon the upper green scale, with appropriate number of zeros added as indicated by the RANGE switch setting. Similarly all ranges beginning with the figures "12" are read upon the lower green scale with appropriate zeros added.

When using the d.c. ranges beginning with the figures "7.5" provided by connecting the Vx2.5 panel jack, correct voltage is that indicated upon the upper green scale multiplied by 2.5, with appropriate zeros added. The high ranges so obtained but beginning with the figure "3" are read directly from the upper green scale with appropriate zeros added.

The decibel scale at the bottom of the meter scale is read directly, selecting the appropriate group of which the right-hand figure corresponds to the RANGE knob position. (For simplicity of meter face a small error has been intentionally allowed in the lowest db. range. This error corresponds to the difference in slope between the 3 V.AC meter scale and the upper green scale. It amounts to less than 2 db. from 0 to +10 db., and increases somewhat below 0 db., where the meter reads low.

PROPER USE OF TEST PRODS

A pair of insulated test prods accompany "VOMAX". One is conventional, black in color, and should **always** be plugged into the COM-GND jack. The second is red, and is of special design in that its circuit-contacting metal tip may be screwed into either end of the red prod sleeve. This tip must be inserted properly if serious error is to be avoided.

For all measurements except d.c. voltage screw the tip into the end nearest the point of rubber cord emergence.

For d.c. voltage measurement screw the tip into the far end of the red prod (the end furthest distant from the point of cord emergence).

This shift of red prod tip position allows one prod to do the work of two. When the tip is screwed into the cord end it connects directly to the cord, as for a.c. volts, ohms and ma. measurements. When the metal tip is screwed into the far end of the red prod a 1 megohm 1% resistor isolates it from the connecting cord, and so isolates the capacity of the instrument itself from any circuit under measurement. This permits measurement of d.c. operating voltages directly at the tube socket connections in an operating radio receiver without upsetting circuit behavior. Meter calibration is made at the factory with this 1 megohm resistor in the red prod in circuit upon d.c. voltage ranges, with it out of circuit on all other functions. If d.c. voltages are measured with the prod tip in the cord end of the red prod the meter will read 2% high.

INITIAL ADJUSTMENTS

Examine meter upon unpacking to make sure pointer reads exactly zero. If it does not, bring it to zero by adjusting the screw found on the meter housing at bottom center. If this mechanical zero-set operation is necessary, tap the meter as it is made to make sure that the pointer returns to exact zero after adjustment.

Insert mains plug into outlet providing 105/125 volts, 50/60 cycle a.c. power only. (For higher mains voltage see Page 1).

Turn ADJ. Ω knob just far enough to right from OFF to cause pilot light above this knob to light.

Allow two or three minutes for "VOMAX" tubes to warm up.

Set FUNCTION knob to +DC.

Set RANGE knob to 3V.

Set SET V-ZERO knob to bring meter pointer exactly to zero on the meter scale.

Rotate RANGE knob through all six positions and note insignificant change of meter zero reading. (ALWAYS ZERO METER ON 3 VOLT +DC RANGE.)

Shift FUNCTION knob to DC— and note absence of zero shift as RANGE switch is rotated.

With zero established as above, set FUNCTION knob to Ω position RANGE to 2K Ω, and set ADJ. Ω knob to bring meter pointer exactly over 3.0 graduation on 3V AC scale. Rotate range knob and note absence of shift in meter reading.

Turn FUNCTION knob back to +DC, RANGE knob to 3V, and note zero. If it has shifted due to failing to allow sufficient time for "VOMAX" tubes to attain proper operating temperature, reset zero with SET-V-ZERO knob. Now set FUNCTION knob to AC and note constancy of zero reading as RANGE switch is rotated through all ranges.

(NOTE — AC and DC meter zero readings will differ less than 2% when tubes are new and when AC balance resistor R42 is properly set, as when "VOMAX" leaves the factory. As tubes age AC and DC zero readings will tend to separate slightly. Until this difference becomes significant it may be ignored or may be compensated for by readjustment of SET-V-ZERO knob for AC. When it exceeds 2% proceed as follows: set zero on +DC, 3V RANGE, shift FUNCTION knob to AC, adjust R42 to bring meter pointer to zero.)

Now insert the red test lead into the +V —Ω —MA jack and observe the flickering meter reading obtained upon the 3V ranges, DC or AC. This is not an indication of meter instability, for in setting zero the meter was entirely stable — remained so until the red prod was inserted in +V —Ω —MA jack. This flickering reading as the red prod is handled, touched, or moved about is simply a proof both of the high input resistance and the high sensitivity of "VOMAX" — both sufficiently high to reveal electrostatic pickup upon the short test lead itself. Check this fact by inserting the tip of the red prod into the COM-GND jack, when meter pointer will fall to zero.

With FUNCTION knob set to AC, withdraw r.f. diode probe from its panel socket and note the absence of zero shift. Touch the probe tip with the finger and note the meter flicker — the measure of high input resistance and high sensitivity. Short-circuit the probe tip to its shell and observe how the meter pointer falls to zero.

D.C. VOLTAGE MEASUREMENTS

Set FUNCTION and RANGE knobs to appropriate settings and contact the black and red prod tips (tip in far end of red prod) to the source of voltage to be measured, black **always** to chassis or common circuit ground, red to "hot" or "high" side of circuit. If meter reads in wrong direction, shift FUNCTION knob from +DC to DC—, or vice versa.

Check protection of meter against overload burnout by applying anything up to 3000 volts to the test prods with RANGE switch set to 3V. (Do not leave overload on meter for any length of time, for meter can be injured by lengthy overload.)

Gain familiarity with operation of the high voltage Vx2.5 ranges by measuring some d.c. voltage as above, then remeasure it after shifting red prod lead to Vx2.5 jack, notice the 60% reduction in meter reading when so measured (60% low since meter reading must be multiplied by 2.5 to obtain correct voltage when reading any "3" RANGE on upper green scale; "3" meter scales are correct for "12" RANGES when using Vx2.5 jack).

A.C. VOLTAGE MEASUREMENTS

Proceed as above with R.F. PROBE in its panel socket, using red and black test prods (tip in cord end of red prod). If a radio receiver or audio amplifier is handy, note how "VOMAX" will measure not only a.c. mains voltages, but a.f. voltages present at grids and plates as well.

In measuring a.c. voltages on the 1200 V range, contact the test prod to such high voltage briefly and as infrequently as possible to avoid damaging overload upon the 6AL5 rectifier tube. This range has been

efficiently and usefully obtained at the expense of possible deterioration on the 6AL5 tube if it is used excessively.

R.F. VOLTAGE MEASUREMENTS

Withdraw R.F. PROBE from "VOMAX" and measure r.f. voltages present in a radio receiver tuned to a strong signal by contacting the probe tip to grid or plate while probe shell simultaneously contacts chassis ground.

Since the R.F. PROBE adds about 8 mmfd. to any circuit to which it is contacted, a true voltage measurement will require temporary retuning of the trimmer capacitor tuning the circuit being measured to offset this added capacity. Once the measurement has been made the trimmer may be retuned to its original setting (or proper setting if it has shifted over time) by contacting the R.F. PROBE to a following tube grid or plate and returning the upset trimmer to the point of greatest voltage reading on "VOMAX".

RESISTANCE MEASUREMENTS

Set FUNCTION knob to Ω, RANGE knob to appropriate range, set ADJ. Ω knob to full-scale meter reading (if not previously done after setting SET-V-ZERO knob in +DC, 3V positions) and contact test prods to resistance to be measured. Read resistance directly on top meter scale, adding appropriate zeros as determined by setting of RANGE knob.

(NOTE — In checking battery-operated, low-current tubes for filament continuity DO NOT use the 2K Ω range for this applies nearly 3 volts to such filaments and may burn them out. Use the 20K Ω range, or an even higher one. This will check continuity properly and avoid burnout of battery tubes.)

Use the 2K Ω range no more than necessary, since load on ohmmeter dry batteries is greatest upon this range.

Ohmmeter accuracy being greatest at mid-scale, most accurate resistance measurements will result when a range is used which yields a reading thereabouts. "VOMAX" has sufficient resistance ranges to usually make this convenient.

When measuring resistance below 1 ohm, allow for resistance of test leads by noting resistance reading when their tips are touched together, and subtract this value of resistance from the measured value of the resistor being measured.

INSULATION RESISTANCE MEASUREMENTS

The 2000 megohm range allows measurements of leakage in capacitors, transformers, cables and insulation generally which have heretofore been almost impossible to the service technician. This range may be greatly extended by the addition of an external source of d.c. voltage (a battery or a radio receiver power supply). To measure resistances above 1000 or 2000 megohms, first measure the voltage (using COM-GND and +V −Ω −MA jacks only) of the external d.c. source used and note same. Then upon a low range of "VOMAX", measure the voltage which may appear when the capacitor (or the insulator) is connected between the voltage source and the red test prod inserted in +V −Ω −MA jack. The resistance in megohms of the insulator (?) will be given by the formula

$$\text{UNKNOWN RESISTANCE} = 51 \text{ X } \frac{\text{Source voltage} - \text{series voltage}}{\text{series voltage}}$$

For example, suppose a source of 300 volts (read on +DC, 300V settings) and a series voltage of 1.2 volts (read on +DC, 3V settings with test specimen connected between red test prod and positive terminal of voltage source), then

$$\text{UNKNOWN RESISTANCE} = 51 \text{ X } \frac{300 - 1.2}{1.2} = 12{,}699 \text{ megohms}$$

DIRECT CURRENT MEASUREMENTS

Set FUNCTION knob to MA, RANGE knob to 12A, insert black test prod lead into COM-GND jack and red test lead into 12A jack. Pass current to be measured through test prods and note meter reading. If current is too low to deflect meter usefully, shift red prod to +V −Ω −MA jack and turn RANGE knob to left, one position at a time, until useful reading is obtained.

(NOTE — ALWAYS proceed as above in making current measurements. The meter has no protection against overload in current measurements. Starting with RANGE knob set to too low a range can result in immediate meter burn-out. It is better to start out in current measurement on the highest range and spend a few seconds reducing range to obtain final reading than to hurry things and ruin the entire instrument.)

DECIBEL MEASUREMENTS

Set FUNCTION knob to AC, RANGE knob to selected db. range, and contact black and red prods to a.f. power source to be measured.

NOTE: As a db. meter "VOMAX" contains its own d.c. isolating capacitor. Its impedance is so high as not to noticeably load any usual power amplifier output circuit. Such amplifier output circuit must be terminated in its own specified output impedance in the form of usual load such as a loud-speaker voice coil, or in a non-inductive resistor of resistance equal to amplifier output impedance.

"VOMAX" will indicate db. directly upon its meter scale when connected across a 600 ohm amplifier output upon the basis of 1 milliwatt =0 db. In most cases amplifier output will not be 600 ohms, but some lower value suitable for direct connection to a loud-speaker voice coil. To read db. correctly across impedances other than 600 ohms, ADD the db. figure below to the meter indication when measurements are made across the corresponding impedance.

OUTPUT IMPEDANCE	ADD DB.	OUTPUT IMPEDANCE	ADD DB.
600	0	30	13.0
500	1.08	25	13.8
400	1.3	20	14.7
300	3.0	16	15.7
250	3.8	10	17.7
200	4.7	8	18.75
150	6.0	6	20.0
125	6.8	5	20.8
100	7.7	4	21.7
70	9.33	2.5	23.8
50	10.8	2.0	24.7

Power output in watts may be determined as

$$\text{WATTS} = \frac{\text{Output Voltage Squared}}{\text{Load Impedance}}$$

For example, the measured voltage across an 8-ohm voice coil load is 2 volts.

$$\text{WATTS} = \frac{2^2}{8} = \frac{4}{8} = .5 \text{ watts}$$

POWER INPUT MEASUREMENT

"VOMAX" can be used as an a.c. (or r.f.) ammeter to determine approximate power input to a radio receiver, etc. This involves measurement of the a.c. voltage drop across a low resistance resistor connected in series with the mains input to the equipment drawing power. Such resistor should be of low resistance in order that only a volt or two at most out of 117 nominal input volts appears across it.

For example, 2 ohms placed in series with a receiver power input circuit shows a voltage drop measured across it of 1.1 volts,

$$I = \frac{E}{R} \quad \frac{1.1}{2} = .55 \text{ amperes}$$

Measure the voltage across the receiver mains input and finding it to be 115 volts for example, multiplying volts by amperes gives power input in watts

$$115 \text{ volts X } .55 \text{ amperes} = 63.25 \text{ watts.}$$

This would be true if the receiver were a pure resistive load. This is substantially true for an a.c./d.c. receiver. An a.c. receiver having a power transformer presents a reactive load, and the statement for power input is not therefore strictly true. It is close enough in most cases to yield a good approximation of power input in watts, however.

By the same method, substituting a series capacitor in an antenna lead, for example, r.f. current may be measured, and power computed if load impedance is known.

VISUAL DYNAMIC SIGNAL TRACING

Measurement of a.c. heater voltages and d.c. grid, cathode, screen and plate voltages is the first step in serious receiver servicing. Check of the supply voltages so measured against the set manufacturers circuit diagram test voltage chart will reveal deteriorated tubes, faulty resistors, capacitors, transformers, reactors and open- or short-circuits. In the majority of cases of trouble these measurements, made with such a high resistance meter as "VOMAX", will localize the trouble and allow immediate replacement of the faulty part. The high resistance of "VOMAX" on d.c. voltage measurements is of inestimable advantage in checking a.v.c. systems, wherein the development of leakage in an a.v.c. bypass capacitor cuts down the a.v.c. voltage on one or more tubes. Such faults can be rapidly located by "VOMAX" through direct measurement of a.v.c. voltage at each successive controlled grid. Measure questionable resistors, and leakage resistance of capacitors.

When the procedure above shows everything to be correct, but operation poor, dynamic signal tracing becomes the service technicians invaluable aid. Actually this is nothing more than the measurement of the received signal voltage itself at every grid and plate successively through the entire amplifying chain of tubes in a radio receiver. Obviously if amplifier tubes are actually amplifying the signal voltage will appear greater as the R.F.PROBE is moved along successively from antenna input to power amplifier plate, circuit by circuit.

Quantitative signal tracing involves application of a strong signal from a local broadcast station or signal generator to the receiver input and the measurement of this signal voltage across antenna and ground, then across first grid to ground. The increase or decrease in voltage is the direct measure of gain or loss of antenna transformer. The same process is repeated for every amplifying stage in the receiver. Each measure-

enable the veriest tyro to operate the instrument in practically all routine measurements. A complete understanding of all controls and functions will insure greatest satisfaction, however.

FUNCTION knob (switches S1a through S1f) has five positions. Its setting determines the type of measurements to be made. AC position is for a.c., r.f. and d.b. measurements. The COM-GND jack is **always** connected through the black test prod to the chassis or common ground of the equipment under test. With FUNCTION knob in +DC position "VOMAX" will measure selected d.c. voltages upon application of the tip screwed into the far end of the red test prod to any point of voltage positive with respect to chassis of equipment under test. FUNCTION knob in DC− position will measure the same range of d.c. voltages, but negative with respect to equipment chassis. FUNCTION knob thus reverses d.c. polarity when required and makes unnecessary reversal of test leads. Ω position of FUNCTION knob provides for resistance measurements; MA position provides for direct current measurements.

RANGE KNOB (switches S2a through S2e) selects the desired voltage, resistance or current range. Its six positions are so clearly identified as to require little comment. It is merely necessary to set RANGE knob to the position providing the full-scale meter range desired for any particular type of measurement.

PANEL JACKS

Two of the four jacks at the upper left of the panel provide additional ranges when correctly utilized. The COM-GND jack is common to all except r.f. measurements (r.f. probe withdrawn from instrument). It is grounded to "VOMAX" panel and circuit. By means of the black test lead it should be connected to the chassis or common grounded circuit of equipment under test. The red test prod with its small cord tip inserted into the +V − Ω −MA jack provides the remaining meter connection to the circuit being tested.

The 12 ampere direct current range is obtained between the COM-GND (negative) and 12A (positive) jacks.

The six positive and six negative (polarity determined by FUNCTION switch position) d.c. voltage ranges of 7.5, 30, 75, 300, 750 and 3000 volts are obtained between COM-GND (negative) and Vx2.5 (positive) jacks.

READING METER

The top scale is graduated directly in ohms from 0 to 2,000. The six RANGE knob positions yield six different resistance ranges differing only in the number of zeros to be added to the scale figures, the full-scale reading in each case being directly indicated by the RANGE knob figures.

The 3-volt a.c. range only is read on the scale immediately below the ohms figures.

All other voltage ranges, and direct current as well, are read on the green center scales. The graduations upon upper and lower green scales are identically spaced, the scales being linear. All voltage ranges beginning with the figure "3" are read upon the upper green scale, with appropriate number of zeros added as indicated by the RANGE switch setting. Similarly all ranges beginning with the figures "12" are read upon the lower green scale with appropriate zeros added.

When using the d.c. ranges beginning with the figures "7.5" provided by connecting the Vx2.5 panel jack, correct voltage is that indicated upon the upper green scale multiplied by 2.5, with appropriate zeros added. The high ranges so obtained but beginning with the figure "3" are read directly from the upper green scale with appropriate zeros added.

The decibel scale at the bottom of the meter scale is read directly, selecting the appropriate group of which the right-hand figure corresponds to the RANGE knob position. (For simplicity of meter face a small error has been intentionally allowed in the lowest db. range. This error corresponds to the difference in slope between the 3 V.AC meter scale and the upper green scale. It amounts to less than 2 db. from 0 to +10 db., and increases somewhat below 0 db., where the meter reads low.

PROPER USE OF TEST PRODS

A pair of insulated test prods accompany "VOMAX". One is conventional, black in color, and should **always** be plugged into the COM-GND jack. The second is red, and is of special design in that its circuit-contacting metal tip may be screwed into either end of the red prod sleeve. This tip must be inserted properly if serious error is to be avoided.

For all measurements except d.c. voltage screw the tip into the end nearest the point of rubber cord emergence.

For d.c. voltage measurement screw the tip into the far end of the red prod (the end furthest distant from the point of cord emergence).

This shift of red prod tip position allows one prod to do the work of two. When the tip is screwed into the cord end it connects directly to the cord, as for a.c. volts, ohms and ma. measurements. When the metal tip is screwed into the far end of the red prod a 1 megohm 1% resistor isolates it from the connecting cord, and so isolates the capacity of the instrument itself from any circuit under measurement. This permits measurement of d.c. operating voltages directly at the tube socket connections in an operating radio receiver without upsetting circuit behavior. Meter calibration is made at the factory with this 1 megohm resistor in the red prod in circuit upon d.c. voltage ranges, with it out of circuit on all other functions. If d.c. voltages are measured with the prod tip in the cord end of the red prod the meter will read 2% high.

INITIAL ADJUSTMENTS

Examine meter upon unpacking to make sure pointer reads exactly zero. If it does not, bring it to zero by adjusting the screw found on the meter housing at bottom center. If this mechanical zero-set operation is necessary, tap the meter as it is made to make sure that the pointer returns to exact zero after adjustment.

Insert mains plug into outlet providing 105/125 volts, 50/60 cycle a.c. power only. (For higher mains voltage see Page 1).

Turn ADJ. Ω knob just far enough to right from OFF to cause pilot light above this knob to light.

Allow two or three minutes for "VOMAX" tubes to warm up.

Set FUNCTION knob to +DC.

Set RANGE knob to 3V.

Set SET V-ZERO knob to bring meter pointer exactly to zero on the meter scale.

Rotate RANGE knob through all six positions and note insignificant change of meter zero reading. (ALWAYS ZERO METER ON 3 VOLT +DC. RANGE.)

Shift FUNCTION knob to DC− and note absence of zero shift as RANGE switch is rotated.

With zero established as above, set FUNCTION knob to Ω position RANGE to 2K Ω, and set ADJ. Ω knob to bring meter pointer exactly over 3.0 graduation on 3V AC scale. Rotate range knob and note absence of shift in meter reading.

Turn FUNCTION knob back to +DC, RANGE knob to 3V, and note zero. If it has shifted due to failing to allow sufficient time for "VOMAX" tubes to attain proper operating temperature, reset zero with SET-V-ZERO knob. Now set FUNCTION knob to AC and note constancy of zero reading as RANGE switch is rotated through all ranges.

(NOTE — AC and DC meter zero readings will differ less than 2% when tubes are new and when AC balance resistor R42 is properly set, as when "VOMAX" leaves the factory. As tubes age AC and DC zero readings will tend to separate slightly. Until this difference becomes significant it may be ignored or may be compensated for by readjustment of SET-V-ZERO knob for AC. When it exceeds 2% proceed as follows: set zero on +DC, 3V RANGE, shift FUNCTION knob to AC, adjust R42 to bring meter pointer to zero.)

Now insert the red test lead into the +V —Ω —MA jack and observe the flickering meter reading obtained upon the 3V ranges, DC or AC. This is not an indication of meter instability, for in setting zero the meter was entirely stable — remained so until the red prod was inserted in +V −Ω −MA jack. This flickering reading as the red prod is handled, touched, or moved about is simply a proof both of the high input resistance and the high sensitivity of "VOMAX" — both sufficiently high to reveal electrostatic pickup upon the short test lead itself. Check this fact by inserting the tip of the red prod into the COM-GND jack, when meter pointer will fall to zero.

With FUNCTION knob set to AC, withdraw r.f. diode probe from its panel socket and note the absence of zero shift. Touch the probe tip with the finger and note the meter flicker — the measure of high input resistance and high sensitivity. Short-circuit the probe tip to its shell and observe how the meter pointer falls to zero.

D.C. VOLTAGE MEASUREMENTS

Set FUNCTION and RANGE knobs to appropriate settings and contact the black and red prod tips (tip in far end of red prod) to the source of voltage to be measured, black **always** to chassis or common circuit ground, red to "hot" or "high" side of circuit. If meter reads in wrong direction, shift FUNCTION knob from +DC to DC−, or vice versa.

Check protection of meter against overload burnout by applying anything up to 3000 volts to the test prods with RANGE switch set to 3V. (Do not leave overload on meter for any length of time, for meter can be injured by lengthy overload.)

Gain familiarity with operation of the high voltage Vx2.5 ranges by measuring some d.c. voltage as above, then remeasure it after shifting red prod lead to Vx2.5 jack, notice the 60% reduction in meter reading when so measured (60% low since meter reading must be multiplied by 2.5 to obtain correct voltage when reading any "3" RANGE on upper green scale; "3" meter scales are correct for "12" RANGES when using Vx2.5 jack).

A.C. VOLTAGE MEASUREMENTS

Proceed as above with R.F. PROBE in its panel socket, using red and black test prods (tip in cord end of red prod). If a radio receiver or audio amplifier is handy, note how "VOMAX" will measure not only a.c. mains voltages, but a.f. voltages present at grids and plates as well.

In measuring a.c. voltages on the 1200 V range, contact the test prod to such high voltage briefly and as infrequently as possible to avoid damaging overload upon the 6AL5 rectifier tube. This range has been

efficiently and usefully obtained at the expense of possible deterioration on the 6AL5 tube if it is used excessively.

R.F. VOLTAGE MEASUREMENTS

Withdraw R.F. PROBE from "VOMAX" and measure r.f. voltages present in a radio receiver tuned to a strong signal by contacting the probe tip to grid or plate while probe shell simultaneously contacts chassis ground.

Since the R.F. PROBE adds about 8 mmfd. to any circuit to which it is contacted, a true voltage measurement will require temporary retuning of the trimmer capacitor tuning the circuit being measured to offset this added capacity. Once the measurement has been made the trimmer may be retuned to its original setting (or proper setting if it has shifted over time) by contacting the R.F. PROBE to a following tube grid or plate and returning the upset trimmer to the point of greatest voltage reading on "VOMAX".

RESISTANCE MEASUREMENTS

Set FUNCTION knob to Ω, RANGE knob to appropriate range, set ADJ. Ω knob to full-scale meter reading (if not previously done after setting SET-V-ZERO knob in +DC, 3V positions) and contact test prods to resistance to be measured. Read resistance directly on top meter scale, adding appropriate zeros as determined by setting of RANGE knob.

(NOTE — In checking battery-operated, low-current tubes for filament continuity DO NOT use the 2K Ω range for this applies nearly 3 volts to such filaments and may burn them out. Use the 20K Ω range, or an even higher one. This will check continuity properly and avoid burnout of battery tubes.)

Use the 2K Ω range no more than necessary, since load on ohmmeter dry batteries is greatest upon this range.

Ohmmeter accuracy being greatest at mid-scale, most accurate resistance measurements will result when a range is used which yields a reading thereabouts. "VOMAX" has sufficient resistance ranges to usually make this convenient.

When measuring resistance below 1 ohm, allow for resistance of test leads by noting resistance reading when their tips are touched together, and subtract this value of resistance from the measured value of the resistor being measured.

INSULATION RESISTANCE MEASUREMENTS

The 2000 megohm range allows measurements of leakage in capacitors, transformers, cables and insulation generally which have heretofore been almost impossible to the service technician. This range may be greatly extended by the addition of an external source of d.c. voltage (a battery or a radio receiver power supply). To measure resistances above 1000 or 2000 megohms, first measure the voltage (using COM-GND and +V −Ω −MA jacks only) of the external d.c. source used and note same. Then upon a low range of "VOMAX", measure the voltage which may appear when the capacitor (or the insulator) is connected between the voltage source and the red test prod inserted in +V −Ω −MA jack. The resistance in megohms of the insulator (?) will be given by the formula

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{\text{Source voltage} - \text{series voltage}}{\text{series voltage}}$$

For example, suppose a source of 300 volts (read on +DC, 300V settings) and a series voltage of 1.2 volts (read on +DC, 3V settings with test specimen connected between red test prod and positive terminal of voltage source), then

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{300 - 1.2}{1.2} = 12{,}699 \text{ megohms}$$

DIRECT CURRENT MEASUREMENTS

Set FUNCTION knob to MA, RANGE knob to 12A, insert black test prod lead into COM-GND jack and red test lead into 12A jack. Pass current to be measured through test prods and note meter reading. If current is too low to deflect meter usefully, shift red prod to +V −Ω −MA jack and turn RANGE knob to left, one position at a time, until useful reading is obtained.

(NOTE — ALWAYS proceed as above in making current measurements. The meter has no protection against overload in current measurements. Starting with RANGE knob set to too low a range can result in immediate meter burn-out. It is better to start out in current measurement on the highest range and spend a few seconds reducing range to obtain final reading than to hurry things and ruin the entire instrument.)

DECIBEL MEASUREMENTS

Set FUNCTION knob to AC, RANGE knob to selected db. range, and contact black and red prods to a.f. power source to be measured.

NOTE: As a db. meter "VOMAX" contains its own d.c. isolating capacitor. Its impedance is so high as not to noticeably load any usual power amplifier output circuit. Such amplifier output circuit must be terminated in its own specified output impedance in the form of usual load such as a loud-speaker voice coil, or in a non-inductive resistor of resistance equal to amplifier output impedance.

"VOMAX" will indicate db. directly upon its meter scale when connected across a 600 ohm amplifier output upon the basis of 1 milliwatt =0 db. In most cases amplifier output will not be 600 ohms, but some lower value suitable for direct connection to a loud-speaker voice coil. To read db. correctly across impedances other than 600 ohms, ADD the db. figure below to the meter indication when measurements are made across the corresponding impedance.

OUTPUT IMPEDANCE	ADD DB.	OUTPUT IMPEDANCE	ADD DB.
600	0	30	13.0
500	1.08	25	13.8
400	1.3	20	14.7
300	3.0	16	15.7
250	3.8	10	17.7
200	4.7	8	18.75
150	6.0	6	20.0
125	6.8	5	20.8
100	7.7	4	21.7
70	9.33	2.5	23.8
50	10.8	2.0	24.7

Power output in watts may be determined as

$$\text{WATTS} = \frac{\text{Output Voltage Squared}}{\text{Load Impedance}}$$

For example, the measured voltage across an 8-ohm voice coil load is 2 volts.

$$\text{WATTS} = \frac{2^2}{8} = \frac{4}{8} = .5 \text{ watts}$$

POWER INPUT MEASUREMENT

"VOMAX" can be used as an a.c. (or r.f.) ammeter to determine approximate power input to a radio receiver, etc. This involves measurement of the a.c. voltage drop across a low resistance resistor connected in series with the mains input to the equipment drawing power. Such resistor should be of low resistance in order that only a volt or two at most out of 117 nominal input volts appears across it.

For example, 2 ohms placed in series with a receiver power input circuit shows a voltage drop measured across it of 1.1 volts,

$$I = \frac{E}{R} \quad \frac{1.1}{2} = .55 \text{ amperes}$$

Measure the voltage across the receiver mains input and finding it to be 115 volts for example, multiplying volts by amperes gives power input in watts

115 volts X .55 amperes =63.25 watts.

This would be true if the receiver were a pure resistive load. This is substantially true for an a.c./d.c. receiver. An a.c. receiver having a power transformer presents a reactive load, and the statement for power input is not therefore strictly true. It is close enough in most cases to yield a good approximation of power input in watts, however.

By the same method, substituting a series capacitor in an antenna lead, for example, r.f. current may be measured, and power computed if load impedance is known.

VISUAL DYNAMIC SIGNAL TRACING

Measurement of a.c. heater voltages and d.c. grid, cathode, screen and plate voltages is the first step in serious receiver servicing. Check of the supply voltages so measured against the set manufacturers circuit diagram test voltage chart will reveal deteriorated tubes, faulty resistors, capacitors, transformers, reactors and open- or short-circuits. In the majority of cases of trouble these measurements, made with such a high resistance meter as "VOMAX", will localize the trouble and allow immediate replacement of the faulty part. The high resistance of "VOMAX" on d.c. voltage measurements is of inestimable advantage in checking a.v.c. systems, wherein the development of leakage in an a.v.c. bypass capacitor cuts down the a.v.c. voltage on one or more tubes. Such faults can be rapidly located by "VOMAX" through direct measurement of a.v.c. voltage at each successive controlled grid. Measure questionable resistors, and leakage resistance of capacitors.

When the procedure above shows everything to be correct, but operation poor, dynamic signal tracing becomes the service technicians invaluable aid. Actually this is nothing more than the measurement of the received signal voltage itself at every grid and plate successively through the entire amplifying chain of tubes in a radio receiver. Obviously if amplifier tubes are actually amplifying the signal voltage will appear greater as the R.F.PROBE is moved along successively from antenna input to power amplifier plate, circuit by circuit.

Quantitative signal tracing involves application of a strong signal from a local broadcast station or signal generator to the receiver input and the measurement of this signal voltage across antenna and ground, then across first grid to ground. The increase or decrease in voltage is the direct measure of gain or loss of antenna transformer. The same process is repeated for every amplifying stage in the receiver. Each measure-

enable the veriest tyro to operate the instrument in practically all routine measurements. A complete understanding of all controls and functions will insure greatest satisfaction, however.

FUNCTION knob (switches S1a through S1f) has five positions. Its setting determines the type of measurements to be made. AC position is for a.c., r.f. and d.b. measurements. The COM-GND jack is **always** connected through the black test prod to the chassis or common ground of the equipment under test. With FUNCTION knob in +DC position "VOMAX" will measure selected d.c. voltages upon application of the tip screwed into the far end of the red test prod to any point of voltage positive with respect to chassis of equipment under test. FUNCTION knob in DC— position will measure the same range of d.c. voltages, but negative with respect to equipment chassis. FUNCTION knob thus reverses d.c. polarity when required and makes unnecessary reversal of test leads. Ω position of FUNCTION knob provides for resistance measurements; MA position provides for direct current measurements.

RANGE KNOB (switches S2a through S2e) selects the desired voltage, resistance or current range. Its six positions are so clearly identified as to require little comment. It is merely necessary to set RANGE knob to the position providing the full-scale meter range desired for any particular type of measurement.

PANEL JACKS

Two of the four jacks at the upper left of the panel provide additional ranges when correctly utilized. The COM-GND jack is common to all except r.f. measurements (r.f. probe withdrawn from instrument). It is grounded to "VOMAX" panel and circuit. By means of the black test lead it should be connected to the chassis or common grounded circuit of equipment under test. The red test prod with its small cord tip inserted into the +V — Ω —MA jack provides the remaining meter connection to the circuit being tested.

The 12 ampere direct current range is obtained between the COM-GND (negative) and 12A (positive) jacks.

The six positive and six negative (polarity determined by FUNCTION switch position) d.c. voltage ranges of 7.5, 30, 75, 300, 750 and 3000 volts are obtained between COM-GND (negative) and Vx2.5 (positive) jacks.

READING METER

The top scale is graduated directly in ohms from 0 to 2,000. The six RANGE knob positions yield six different resistance ranges differing only in the number of zeros to be added to the scale figures, the full-scale reading in each case being directly indicated by the RANGE knob figures.

The 3-volt a.c. range only is read on the scale immediately below the ohms figures.

All other voltage ranges, and direct current as well, are read on the green center scales. The graduations upon upper and lower green scales are identically spaced, the scales being linear. All voltage ranges beginning with the figure "3" are read upon the upper green scale, with appropriate number of zeros added as indicated by the RANGE switch setting. Similarly all ranges beginning with the figures "12" are read upon the lower green scale with appropriate zeros added.

When using the d.c. ranges beginning with the figures "7.5" provided by connecting the Vx2.5 panel jack, correct voltage is that indicated upon the upper green scale multiplied by 2.5, with appropriate zeros added. The high ranges so obtained but beginning with the figure "3" are read directly from the upper green scale with appropriate zeros added.

The decibel scale at the bottom of the meter scale is read directly, selecting the appropriate group of which the right-hand figure corresponds to the RANGE knob position. (For simplicity of meter face a small error has been intentionally allowed in the lowest db. range. This error corresponds to the difference in slope between the 3 V.AC meter scale and the upper green scale. It amounts to less than 2 db. from 0 to +10 db., and increases somewhat below 0 db., where the meter reads low.

PROPER USE OF TEST PRODS

A pair of insulated test prods accompany "VOMAX". One is conventional, black in color, and should **always** be plugged into the COM-GND jack. The second is red, and is of special design in that its circuit-contacting metal tip may be screwed into either end of the red prod sleeve. This tip must be inserted properly if serious error is to be avoided.

For all measurements except d.c. voltage screw the tip into the end nearest the point of rubber cord emergence.

For d.c. voltage measurement screw the tip into the far end of the red prod (the end furthest distant from the point of cord emergence).

This shift of red prod tip position allows one prod to do the work of two. When the tip is screwed into the cord end it connects directly to the cord, as for a.c. volts, ohms and ma. measurements. When the metal tip is screwed into the far end of the red prod a 1 megohm 1% resistor isolates it from the connecting cord, and so isolates the capacity of the instrument itself from any circuit under measurement. This permits measurement of d.c. operating voltages directly at the tube socket connections in an operating radio receiver without upsetting circuit behavior. Meter calibration is made at the factory with this 1 megohm resistor in the red prod in circuit upon d.c. voltage ranges, with it out of circuit on all other functions. If d.c. voltages are measured with the prod tip in the cord end of the red prod the meter will read 2% high.

INITIAL ADJUSTMENTS

Examine meter upon unpacking to make sure pointer reads exactly zero. If it does not, bring it to zero by adjusting the screw found on the meter housing at bottom center. If this mechanical zero-set operation is necessary, tap the meter as it is made to make sure that the pointer returns to exact zero after adjustment.

Insert mains plug into outlet providing 105/125 volts, 50/60 cycle a.c. power only. (For higher mains voltage see Page 1).

Turn ADJ. Ω knob just far enough to right from OFF to cause pilot light above this knob to light.

Allow two or three minutes for "VOMAX" tubes to warm up.

Set FUNCTION knob to +DC.

Set RANGE knob to 3V.

Set SET V-ZERO knob to bring meter pointer exactly to zero on the meter scale.

Rotate RANGE knob through all six positions and note insignificant change of meter zero reading. (ALWAYS ZERO METER ON 3 VOLT +DC. RANGE.)

Shift FUNCTION knob to DC— and note absence of zero shift as RANGE switch is rotated.

With zero established as above, set FUNCTION knob to Ω position RANGE to 2K Ω, and set ADJ. Ω knob to bring meter pointer exactly over 3.0 graduation on 3V AC scale. Rotate range knob and note absence of shift in meter reading.

Turn FUNCTION knob back to +DC, RANGE knob to 3V, and note zero. If it has shifted due to failing to allow sufficient time for "VOMAX" tubes to attain proper operating temperature, reset zero with SET-V-ZERO knob. Now set FUNCTION knob to AC and note constancy of zero reading as RANGE switch is rotated through all ranges.

(NOTE — AC and DC meter zero readings will differ less than 2% when tubes are new and when AC balance resistor R42 is properly set, as when "VOMAX" leaves the factory. As tubes age AC and DC zero readings will tend to separate slightly. Until this difference becomes significant it may be ignored or may be compensated for by readjustment of SET-V-ZERO knob for AC. When it exceeds 2% proceed as follows: set zero on +DC, 3V RANGE, shift FUNCTION knob to AC, adjust R42 to bring meter pointer to zero.)

Now insert the red test lead into the +V —Ω —MA jack and observe the flickering meter reading obtained upon the 3V ranges, DC or AC. This is not an indication of meter instability, for in setting zero the meter was entirely stable — remained so until the red prod was inserted in +V —Ω —MA jack. This flickering reading as the red prod is handled, touched, or moved about is simply a proof both of the high input resistance and the high sensitivity of "VOMAX" — both sufficiently high to reveal electrostatic pickup upon the short test lead itself. Check this fact by inserting the tip of the red prod into the COM-GND jack, when meter pointer will fall to zero.

With FUNCTION knob set to AC, withdraw r.f. diode probe from its panel socket and note the absence of zero shift. Touch the probe tip with the finger and note the meter flicker — the measure of high input resistance and high sensitivity. Short-circuit the probe tip to its shell and observe how the meter pointer falls to zero.

D.C. VOLTAGE MEASUREMENTS

Set FUNCTION and RANGE knobs to appropriate settings and contact the black and red prod tips (tip in far end of red prod) to the source of voltage to be measured, black **always** to chassis or common circuit ground, red to "hot" or "high" side of circuit. If meter reads in wrong direction, shift FUNCTION knob from +DC to DC—, or vice versa.

Check protection of meter against overload burnout by applying anything up to 3000 volts to the test prods with RANGE switch set to 3V. (Do not leave overload on meter for any length of time, for meter can be injured by lengthy overload.)

Gain familiarity with operation of the high voltage Vx2.5 ranges by measuring some d.c. voltage as above, then remeasure it after shifting red prod lead to Vx2.5 jack, notice the 60% reduction in meter reading when so measured (60% low since meter reading must be multiplied by 2.5 to obtain correct voltage when reading any "3" RANGE on upper green scale; "3" meter scales are correct for "12" RANGES when using Vx2.5 jack).

A.C. VOLTAGE MEASUREMENTS

Proceed as above with R.F. PROBE in its panel socket, using red and black test prods (tip in cord end of red prod). If a radio receiver or audio amplifier is handy, note how "VOMAX" will measure not only a.c. mains voltages, but a.f. voltages present at grids and plates as well.

In measuring a.c. voltages on the 1200 V range, contact the test prod to such high voltage briefly and as infrequently as possible to avoid damaging overload upon the 6AL5 rectifier tube. This range has been

efficiently and usefully obtained at the expense of possible deterioration on the 6AL5 tube if it is used excessively.

R.F. VOLTAGE MEASUREMENTS

Withdraw R.F. PROBE from "VOMAX" and measure r.f. voltages present in a radio receiver tuned to a strong signal by contacting the probe tip to grid or plate while probe shell simultaneously contacts chassis ground.

Since the R.F. PROBE adds about 8 mmfd. to any circuit to which it is contacted, a true voltage measurement will require temporary retuning of the trimmer capacitor tuning the circuit being measured to offset this added capacity. Once the measurement has been made the trimmer may be retuned to its original setting (or proper setting if it has shifted over time) by contacting the R.F. PROBE to a following tube grid or plate and returning the upset trimmer to the point of greatest voltage reading on "VOMAX".

RESISTANCE MEASUREMENTS

Set FUNCTION knob to Ω, RANGE knob to appropriate range, set ADJ. Ω knob to full-scale meter reading (if not previously done after setting SET-V-ZERO knob in +DC, 3V positions) and contact test prods to resistance to be measured. Read resistance directly on top meter scale, adding appropriate zeros as determined by setting of RANGE knob.

(NOTE — In checking battery-operated, low-current tubes for filament continuity DO NOT use the 2K Ω range for this applies nearly 3 volts to such filaments and may burn them out. Use the 20K Ω range, or an even higher one. This will check continuity properly and avoid burnout of battery tubes.)

Use the 2K Ω range no more than necessary, since load on ohmmeter dry batteries is greatest upon this range.

Ohmmeter accuracy being greatest at mid-scale, most accurate resistance measurements will result when a range is used which yields a reading thereabouts. "VOMAX" has sufficient resistance ranges to usually make this convenient.

When measuring resistance below 1 ohm, allow for resistance of test leads by noting resistance reading when their tips are touched together, and subtract this value of resistance from the measured value of the resistor being measured.

INSULATION RESISTANCE MEASUREMENTS

The 2000 megohm range allows measurements of leakage in capacitors, transformers, cables and insulation generally which have heretofore been almost impossible to the service technician. This range may be greatly extended by the addition of an external source of d.c. voltage (a battery or a radio receiver power supply). To measure resistances above 1000 or 2000 megohms, first measure the voltage (using COM-GND and +V −Ω −MA jacks only) of the external d.c. source used and note same. Then upon a low range of "VOMAX", measure the voltage which may appear when the capacitor (or the insulator) is connected between the voltage source and the red test prod inserted in +V −Ω −MA jack. The resistance in megohms of the insulator (?) will be given by the formula

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{\text{Source voltage — series voltage}}{\text{series voltage}}$$

For example, suppose a source of 300 volts (read on +DC, 300V settings) and a series voltage of 1.2 volts (read on +DC, 3V settings with test specimen connected between red test prod and positive terminal of voltage source), then

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{300 - 1.2}{1.2} = 12{,}699 \text{ megohms}$$

DIRECT CURRENT MEASUREMENTS

Set FUNCTION knob to MA, RANGE knob to 12A, insert black test prod lead into COM-GND jack and red test lead into 12A jack. Pass current to be measured through test prods and note meter reading. If current is too low to deflect meter usefully, shift red prod to +V −Ω −MA jack and turn RANGE knob to left, one position at a time, until useful reading is obtained.

(NOTE — ALWAYS proceed as above in making current measurements. The meter has no protection against overload in current measurements. Starting with RANGE knob set to too low a range can result in immediate meter burn-out. It is better to start out in current measurement on the highest range and spend a few seconds reducing range to obtain final reading than to hurry things and ruin the entire instrument.)

DECIBEL MEASUREMENTS

Set FUNCTION knob to AC, RANGE knob to selected db. range, and contact black and red prods to a.f. power source to be measured.

NOTE: As a db. meter "VOMAX" contains its own d.c. isolating capacitor. Its impedance is so high as not to noticeably load any usual power amplifier output circuit. Such amplifier output circuit must be terminated in its own specified output impedance in the form of usual load such as a loud-speaker voice coil, or in a non-inductive resistor of resistance equal to amplifier output impedance.

"VOMAX" will indicate db. directly upon its meter scale when connected across a 600 ohm amplifier output upon the basis of 1 milliwatt =0 db. In most cases amplifier output will not be 600 ohms, but some lower value suitable for direct connection to a loud-speaker voice coil. To read db. correctly across impedances other than 600 ohms, ADD the db. figure below to the meter indication when measurements are made across the corresponding impedance.

OUTPUT IMPEDANCE	ADD DB.	OUTPUT IMPEDANCE	ADD DB.
600	0	30	13.0
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250	3.8	10	17.7
200	4.7	8	18.75
150	6.0	6	20.0
125	6.8	5	20.8
100	7.7	4	21.7
70	9.33	2.5	23.8
50	10.8	2.0	24.7

Power output in watts may be determined as

$$\text{WATTS} = \frac{\text{Output Voltage Squared}}{\text{Load Impedance}}$$

For example, the measured voltage across an 8-ohm voice coil load is 2 volts.

$$\text{WATTS} = \frac{2^2}{8} = \frac{4}{8} = .5 \text{ watts}$$

POWER INPUT MEASUREMENT

"VOMAX" can be used as an a.c. (or r.f.) ammeter to determine approximate power input to a radio receiver, etc. This involves measurement of the a.c. voltage drop across a low resistance resistor connected in series with the mains input to the equipment drawing power. Such resistor should be of low resistance in order that only a volt or two at most out of 117 nominal input volts appears across it.

For example, 2 ohms placed in series with a receiver power input circuit shows a voltage drop measured across it of 1.1 volts,

$$I = \frac{E}{R} \quad \frac{1.1}{2} = .55 \text{ amperes}$$

Measure the voltage across the receiver mains input and finding it to be 115 volts for example, multiplying volts by amperes gives power input in watts

$$115 \text{ volts} \times .55 \text{ amperes} = 63.25 \text{ watts.}$$

This would be true if the receiver were a pure resistive load. This is substantially true for an a.c./d.c. receiver. An a.c. receiver having a power transformer presents a reactive load, and the statement for power input is not therefore strictly true. It is close enough in most cases to yield a good approximation of power input in watts, however.

By the same method, substituting a series capacitor in an antenna lead, for example, r.f. current may be measured, and power computed if load impedance is known.

VISUAL DYNAMIC SIGNAL TRACING

Measurement of a.c. heater voltages and d.c. grid, cathode, screen and plate voltages is the first step in serious receiver servicing. Check of the supply voltages so measured against the set manufacturers circuit diagram test voltage chart will reveal deteriorated tubes, faulty resistors, capacitors, transformers, reactors and open- or short-circuits. In the majority of cases of trouble these measurements, made with such a high resistance meter as "VOMAX", will localize the trouble and allow immediate replacement of the faulty part. The high resistance of "VOMAX" on d.c. voltage measurements is of inestimable advantage in checking a.v.c. systems, wherein the development of leakage in an a.v.c. bypass capacitor cuts down the a.v.c. voltage on one or more tubes. Such faults can be rapidly located by "VOMAX" through direct measurement of a.v.c. voltage at each successive controlled grid. Measure questionable resistors, and leakage resistance of capacitors.

When the procedure above shows everything to be correct, but operation poor, dynamic signal tracing becomes the service technicians invaluable aid. Actually this is nothing more than the measurement of the received signal voltage itself at every grid and plate successively through the entire amplifying chain of tubes in a radio receiver. Obviously if amplifier tubes are actually amplifying the signal voltage will appear greater as the R.F.PROBE is moved along successively from antenna input to power amplifier plate, circuit by circuit.

Quantitative signal tracing involves application of a strong signal from a local broadcast station or signal generator to the receiver input and the measurement of this signal voltage across antenna and ground, then across first grid to ground. The increase or decrease in voltage is the direct measure of gain or loss of antenna transformer. The same process is repeated for every amplifying stage in the receiver. Each measure-

ment preferably includes a tube and coupling transformer, and is most easily made first at one grid, then at the immediately following grid. The gain or loss is the larger voltage observed divided by the smaller.

Because of the inescapable though small input capacitance of any vacuum-tube voltmeter R.F.PROBE, shunting the probe across grid to ground of an r.f. or i.f. stage adds capacity thereto — about 8 mmfd. in the case of "VOMAX" R.F.PROBE contacted directly tip to grid or plate and shell to chassis. This added capacity will slightly detune the circuit being measured and so reduce the voltage appearing across it at the instant of measurement. In preliminary qualitative tests this effect may often be ignored, but for precise measurements the trimmer of the circuit across which voltage is being measured should be adjusted, while the R.F.PROBE is contacted to the circuit, to give maximum voltage reading. The trimmer may be reset by moving the R.F.PROBE along to the next grid circuit and then readjusting the preceding circuit trimmer for greatest voltage reading.

In visual dynamic signal tracing as above the effect of the receivers a.v.c. system must be allowed for. When a strong signal is applied to the antenna input the a.v.c., if functioning properly reduces the gain of each stage enough to hold the i.f. input to the second detector substantially constant. To measure true stage gains the a.v.c. must be rendered inoperative by connecting a jumper from ground to the r.f./i.f. grid side of the first a.v.c. series filter resistor.

From the above it is apparent that a.v.c operation may be accurately checked, and curves plotted if desired, by contacting "VOMAX" R.F.PROBE to the second detector input, retuning the appropriate i.f. trimmer temporarily to give greatest voltage reading, and then reducing antenna input in progressive steps. Plotting a curve of second detector input voltage versus r.f. antenna input voltage gives a basic a.v.c. curve.

In preliminary visual dynamic signal tracing it is convenient to dispense with the necessity of retrimming each circuit measured when the R.F.PROBE is contacted to it. This is made possible by reducing the 8 mmfd. input capacitance of the R.F.PROBE to some value so low as not to necessitate retrimming. A capacitor of .5 to 1 mmfd. placed in series with the R.F.PROBE tip and the grid or plate to be contacted will reduce R.F.PROBE capacitance-loading to a value so low as not to significantly upset the tuning of the circuit being measured. Such a capacitance must be as small in physical size as possible. It is most easily obtained by cutting a length of spaghetti insulating tubing of size which will just slip over the R.F.PROBE tip to a length which will completely cover the tip.

This spaghetti sleeve acts as the dielectric of a small capacitor, the plates of which are formed by the R.F.PROBE tip and the socket lug against which the spaghetti (with tip inside it) is contacted. This is a most effective method of simplifying signal tracing. It reduces the sensitivity of the meter considerably, but the 1 volt obtainable from the average local broadcast station or signal generator will usually be sufficient to give a perceptable meter deflection at antenna, first r.f. grid, or certainly at second r.f. grid.

MISCELLANEOUS TESTS

OSCILLATOR VOLTAGE: The strength of oscillation of a superheterodyne or other oscillator may be measured directly in volts with "VOMAX". Contacting the R.F.PROBE to oscillator grid and ground will give a direct indication of the r.f. voltage being developed by the oscillator. It may also be estimated as the negative d.c. voltage developed at the oscillator grid, FUNCTION switch set to DC−, RANGE to appropriate voltage range, and tip in far end of red prod contacted to grid. The first method measures oscillator r.f. voltage directly, the second is indirect and less desirable. By the direct R.F.PROBE method uncertainty is eliminated. Oscillator voltages over each and every band of a receiver up beyond 100 megacycles may be so measured directly.

A.V.C. VOLTAGE: This important class of measurements has been covered under VISUAL DYNAMIC SIGNAL TRACING. A.v.c. voltages are usually negative with respect to chassis ground. FUNCTION knob should therefore be set to DC−, and red prod with tip in far end successively contacted to a.v.c. load resistor, then to each a.v.c.-controlled grid. A stable and reasonably strong input signal should be employed, as from a local broadcast station or signal generator. IT IS CONVENIENT TO CONNECT "VOMAX" ACROSS THE SECOND DETECTOR, OR A.V.C., LOAD RESISTOR IN ALIGNMENT — WHEN ALIGNMENT SHOULD BE EFFECTED TO GIVE GREATEST METER READING.

FM AND A.F.C. DISCRIMINATOR VOLTAGE: The d.c. voltage developed by the discriminator in FM receivers, and in a.f.c. systems, may be measured directly across the discriminator load resistors with "VOMAX". Because this voltage shifts from positive to negative as signal frequency is varied, a zero-center meter is desirable. When properly aligned to a carrier frequency, discriminator output should be zero. Use of a zero-left meter can indicate deviation in only one direction. "VOMAX" can be converted to a zero-center meter for discriminator voltage measurement by simply adjusting the SET V-ZERO knob to bring the meter pointer up to 0 on the db. scale, when deviations in both directions may be readily observed.

TELEVISION RECEIVER VOLTAGE MEASUREMENTS: All types of voltages in television receiver video and audio channels may be measured by "VOMAX". As a peak-reading a.c. voltmeter "VOMAX" is calibrated in R.M.S. values of the sine wave, or .707 of peak value. It may be employed to measure the peak values of sweep oscillator voltages and of saw-tooth or square-wave sources.

AUDIO VOLTAGES: With R.F.PROBE in panel socket, FUNCTION knob at AC and tip in near end of red prod, audio voltages throughout all successive circuits of an audio amplifier may be measured from 20 cycles on up. At high frequencies, and in resistance-capacitance coupled a.f. amplifiers, the effect of the 50 mmfd. input capacitance of "VOMAX" when so used must be allowed for. In making accurate measurements over a wide frequency range it is desirable to do so with the R.F.PROBE directly. However, the 500 mmfd. input capacitor in the R.F.PROBE is so small as to cause error at usual audio frequencies. This may be obviated if one lead from a capacitor of .025 to .1 mfd. is temporarily soldered to the small screw-head found on the R.F.PROBE ceramic head and the other lead of this capacitor used as the probe tip to the circuit under measurement.

SUPERIMPOSED VOLTAGES: D.C. voltages present in a circuit simultaneously with a.c. voltages, and vice versa, can be independently measured by "VOMAX" with no special precautions. When using a.c. functions the series input capacitor blocks out d.c. When using d.c. functions, the a.c. filter R41, C4 filters out a.c.

INSULATION RESISTANCE: Measurement of insulation resistance of capacitors, transformers, reactors and other insulators has been covered under INSULATION RESISTANCE MEASUREMENTS.

PRECAUTIONS: In order to keep input capacitance to a minimum in AC voltage functions of "VOMAX", and to similarly hold down input capacitance in DC operation, the red test lead has not been shielded. In making measurements on high resistance circuits, therefore, the red test lead should be kept away from a.c. mains conduits or wiring. In AC operation, grasp the red prod at its far end, vice versa in DC. Keep the red lead away from the body. Observation of these precautions, coupled with possible grounding of "VOMAX" panel in extreme cases of local electrostatic fields, will avoid errors due to same while keeping meter capacitance at a minimum.

CAPACITANCE MEASUREMENTS: Accurate capacitance measurement is possible only with a bridge circuit which takes into account both capacitance and resistance; which has a dissipation factor or power factor balance. The same is true for inductance measurements. However, rough but useful capacitance measurements may be made in an emergency with "VOMAX". What is so measured is the capacitance reactance, Cx, of the capacitor under test. The method involves connecting the unknown capacitor and a variable resistor in series across a source of 5 to 120 volts of 60 cycle a.c., and adjusting the resistor until the voltage measured across it equals exactly the voltage measured across the capacitor. The resistor is then measured upon the OHMMETER of "VOMAX" and its value located upon Fig. 4, from which point the capacitance may be read directly. One 3000 ohm rheostat and one 3 megohm rheostat will serve for capacitors between 10 and .01 mfd. (When using 50 cycles, true capacitance is ⅚ of the value so indicated.)

MAINTENANCE

Built of the highest quality parts to close to military standards of excellence, no trouble need be anticipated with "VOMAX" over long periods of time. Accuracy will be well maintained even though the same tubes are used in continuous operation for long periods of time. Variation in and aging of tube characteristics have little effect upon operation.

OHMMETER BATTERIES: Ohmmeter batteries should be replaced when they measure less than 2.2 volts total as measured by +DC FUNCTION, 3V RANGE of "VOMAX" itself or when OHMMETER readings become unstable. Connections to batteries should be unsoldered, old batteries removed, new ones inserted and connections thereto resoldered.

VACUUM TUBES: 6SN7GT Vacuum tubes may be replaced when SET V-ZERO knob will not bring meter pointer to zero, or when zero appears unstable even after 10 to 15 minutes warm-up time. Known-good tubes may be directly substituted for original tubes. The same applies to the 6AL5 R.F.PROBE tube. It should be replaced when no adjustment of R42 only will make AC zero coincident with DC zero. If the first replacement 6AL5 tried will not permit establishing AC zero coincident with DC zero through adjustment of R42 alone, a second tube should be tried. If no second tube is available, required coincidence of AC and DC zeros brought about through adjustment of R42 only may be obtained by interchanging the connections to lugs 2 and 7 at the R.F.PROBE tube socket.

CALIBRATION: Recalibration should practically never be necessary unless the instrument is abused, damaged or its internal RANGE SET resistor adjustments are tampered with. DC calibration may be affected by applying 2 or 3 volts of precisely known d.c. voltage (measured by an external precision laboratory-type meter standard) to the 3V, +DC range of "VOMAX" and then carefully adjusting R22 for identical readings between the external standard meter and "VOMAX" meter. Higher voltage ranges when tested will then be found to be in step.

AC calibration requires an equally good meter having ranges of 2/3, 8/12, 20/30 and 80/120 volts, together with a low-frequency a.c. voltage source within these limits. Having zeroed "VOMAX", calibration consists of applying a definitely known 50 or 60 cycle a.c. voltage to "VOMAX" input, and adjustment of internal a.c. RANGE SET resistors to identicality of meter readings for the four different a.c. voltages on the four meter ranges. Using an external voltage which will give a meter reading somewhere upon the upper ⅓rd of "VOMAX" scale for each of the 3, 12, 30 and 120 volt ranges, adjust the appropriate RANGE

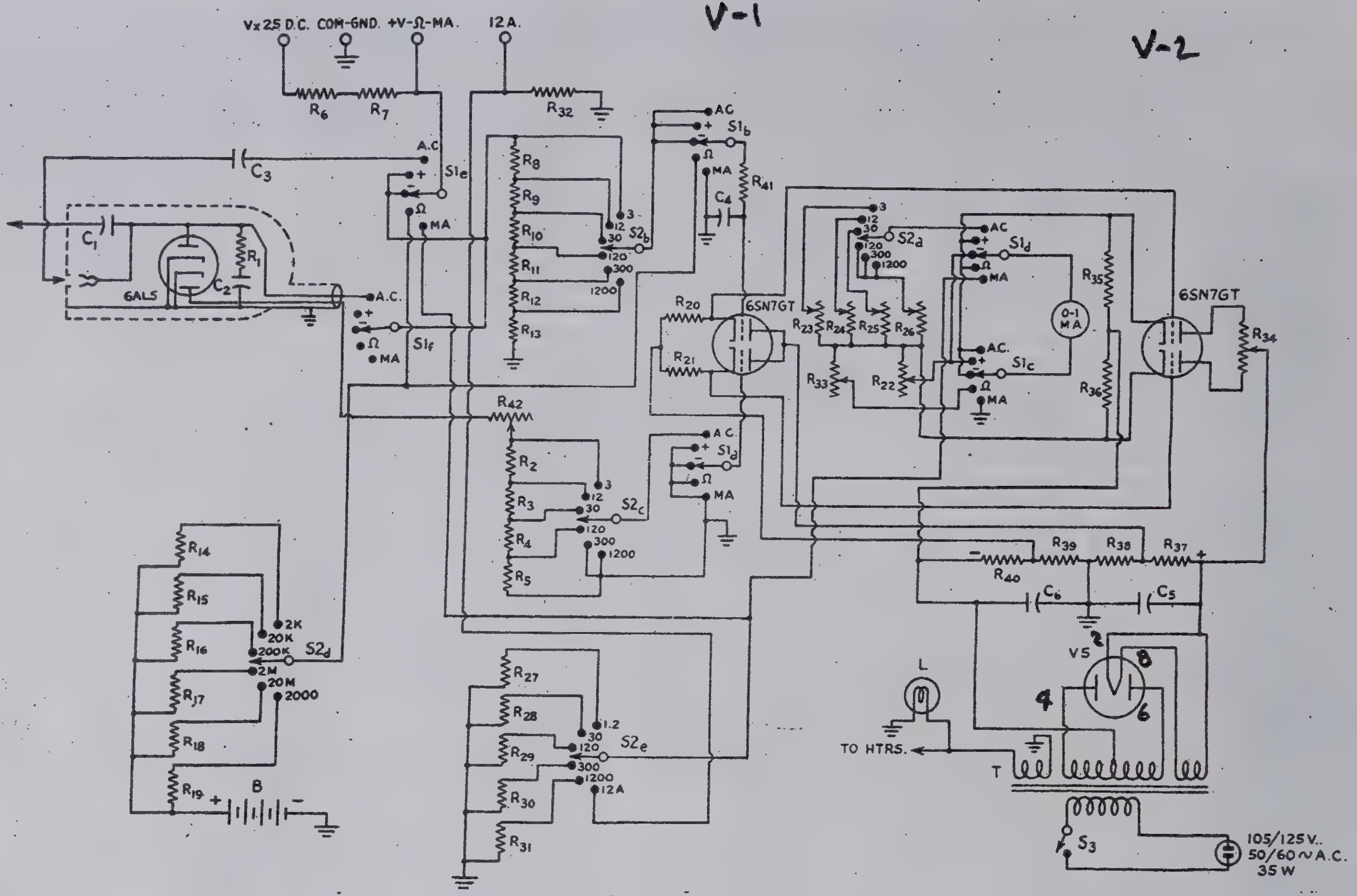


Figure 3

SET resistor for each of these ranges; R23 for 3 volt range, R24 for 12 volt, R25 for 30 volt and R26 for 120 volt range. Adjustment of R26 on the 120 volt range will bring 120, 300 and 1200 volt AC ranges into proper step.

TESTING "VOMAX": The chart appended to Fig. 3 gives voltages correct to 20% which should be observed when the red prod is contacted to the d.c. voltage points listed. Internal a.c. voltages may be similarly measured upon appropriate ranges of "VOMAX" by using both red and black prods to measure mains input voltage, and red prod only for 6.3 volt heater circuits and high voltage power transformer secondaries.

FILTER CAPACITORS: Electrolytic capacitors C5, C6 are polarized. Their + terminals must contact their + spring contactors. Reversal of C5, C6 polarity will ruin them and damage the power transformer and rectifier tube.

CAUTION: HIGH VOLTAGES ARE DEADLY. When measuring high voltages attach black test lead to one side of circuit to be measured, put one hand in pocket, stand on well insulated floor, and holding red test prod lightly between thumb and fore-finger at middle of red prod, contact its tip to high voltage point to be measured. DON'T TAKE CHANCES — YOU HAVE ONLY ONE LIFE — DON'T RISK LOSING IT.

CAUTION: To obtain the extremely useful 1200 volt AC range of "VOMAX" has necessitated operation of the 6AL5 rectifier beyond tube manufacturers' ratings. Extensive tests have revealed no evidence of premature tube deterioration. However, to insure long tube life use the 1200 volt AC range no more than absolutely necessary, and then only briefly. For example, contact prod to source to be measured, read meter, remove prod from source at once.

OPERATING VOLTAGE CHART

Cathode ends of R20, R21 to ground, +2 V d.c.
Cathode ends of R35, R36 to ground, +2 V d.c.
Cathode end of R39 to ground, −17 V d.c.
Cathode end of R40 to ground, −180 V d.c.
Plate end of R38 to ground, +17 V d.c.
Plate end of R37 to ground, +180 V d.c.
Heaters to ground, 6.3 V a.c. (at transformer)
Plates of 5Y3GT to center-tap (tube out of socket) 320 volts a.c.

PARTS LIST

C1 — 0.0005-ufd. silver-mica
C2 — 0.001-ufd. mica
C3 — 0.03-ufd. 3000-volt tubular oil
C4 — 0.005-ufd. mica
C5, C6 — 8-ufd. 350-volt electrolytic
R1 — 20-megohm, ±5 per cent, ¼-watt carbon resistor
R2, R9 — 7.5 megohms, ½ watt metalized resistors*
R3 — 1.5 megohms, ½ watt metalized resistors*
R4, R11 — 750,000 ohms, ½ watt metalized resistors*
R5 — 250,000 ohms ½ watt metalized resistors*
R6, R7, R8 — 37.5 megohms, — watt metalized resistors*
R10 — 3.75 megohms, ½ watt metalized resistors*
R12 — 375,000 ohms, ½ watt metalized resistors*
R13 — 125,000 ohms, ½ watt metalized resistors*
R14 — 10-ohm, 1 per cent ½ watt wire-wound
R15 — 100 ohms, ½ watt metalized resistors*
R16 — 1,000 ohms, ½ watt metalized resistors*
R17 — 10,000 ohms, ½ watt metalized resistors*
R18 — 100,000 ohms, ½ watt metalized resistors*
R19 — 10 megohms, ½ watt metalized resistors*
R20, R21, R41 — 5.1 megohm, ±5 per cent, ½ watt metalized resistor
R22, R23, R24, R25, R26 — 3000 ohm wire-wound potentiometer
R-27 — 258.4 ohm, 1 per cent wire-wound resistor
R28 — 1.758 ohm, 1 per cent wire-wound resistor
R29 — 0.423 ohm, 1 per cent wire wound resistor
R30 — 0.161 ohm, 1 per cent wire-wound resistor
R31 — 0.028 ohm, 1 per cent wire-wound resistor
R32 — Special-Set in test to give 12-ampere range
R33 — 10,000 ohm, wire-wound potentiometer with s.p.s.t. switch
R34 — 3000 ohm wire-wound potentiometer
R35, R36, R37, R40 — 43,000 ohms, ±5 per cent, 2 watt metalized resistors.
R38, R39 — 4,300 ohm, ±5 per cent, ½ watt metalized resistors.
R42 — 10 megohm potentiometer
S1 — 5-position, 6-circuit, 3-section ceramic switch
S2 — 5-circuit, 6-position, 5-section ceramic switch (front section shorting)
T — Power Transformer; 115-volt, 50/60 primary; 5-volts, 2 amp.; 6.3 volts, 1.6 amp.; 640 volts, 50 ma.

*Pairs of I.R.C. BT-½ resistors matched in series to give specified values.

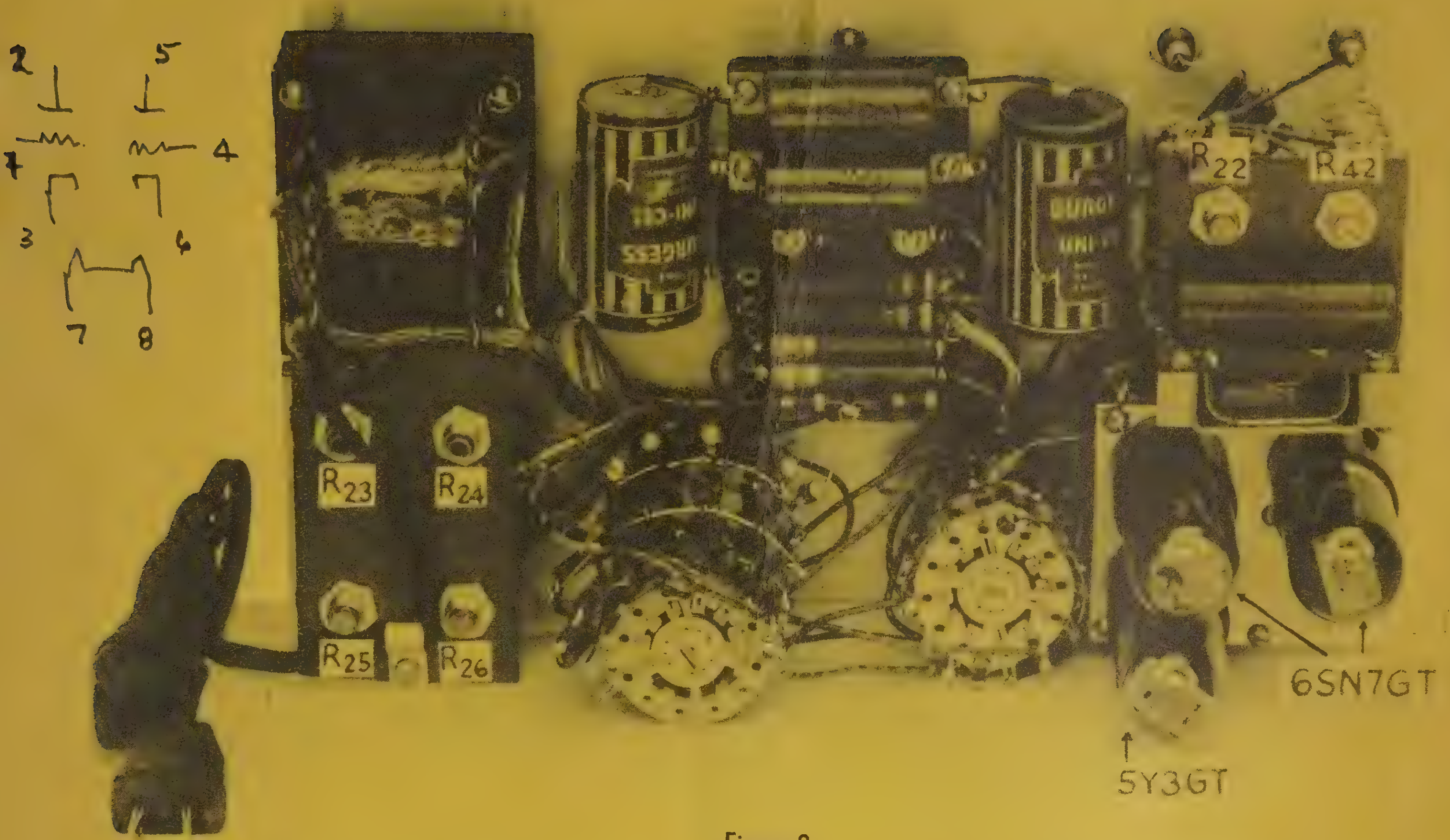
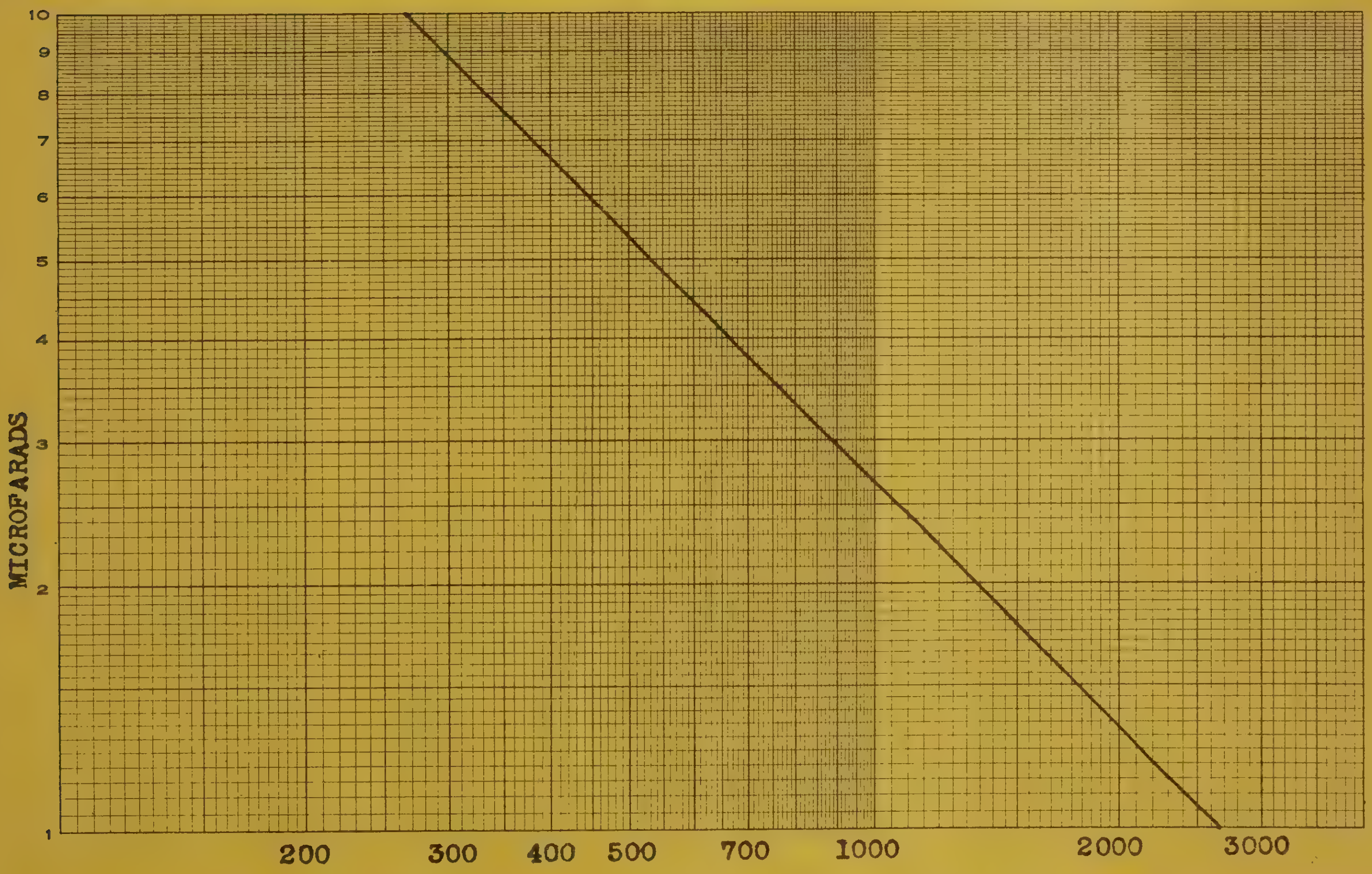

2
5
1
4
3
6
7
8
R22
R42
R23
R24
R25
R26
6SN7GT
5Y3GT

Figure 2



FOR EACH ZERO ADDED TO RESISTANCE (BOTTOM SCALE) ADD ONE DECIMAL POINT IN FRONT OF MICROFARADS

FIGURE 4

6 J 4
6 A 25

enable the veriest tyro to operate the instrument in practically all routine measurements. A complete understanding of all controls and functions will insure greatest satisfaction, however.

FUNCTION knob (switches S1a through S1f) has five positions. Its setting determines the type of measurements to be made. AC position is for a.c., r.f. and d.b. measurements. The COM-GND jack is **always** connected through the black test prod to the chassis or common ground of the equipment under test. With FUNCTION knob in +DC position "VOMAX" will measure selected d.c. voltages upon application of the tip screwed into the far end of the red test prod to any point of voltage positive with respect to chassis of equipment under test. FUNCTION knob in DC— position will measure the same range of d.c. voltages, but negative with respect to equipment chassis. FUNCTION knob thus reverses d.c. polarity when required and makes unnecessary reversal of test leads. Ω position of FUNCTION knob provides for resistance measurements; MA position provides for direct current measurements.

RANGE KNOB (switches S2a through S2e) selects the desired voltage, resistance or current range. Its six positions are so clearly identified as to require little comment. It is merely necessary to set RANGE knob to the position providing the full-scale meter range desired for any particular type of measurement.

PANEL JACKS

Two of the four jacks at the upper left of the panel provide additional ranges when correctly utilized. The COM-GND jack is common to all except r.f. measurements (r.f. probe withdrawn from instrument). It is grounded to "VOMAX" panel and circuit. By means of the black test lead it should be connected to the chassis or common grounded circuit of equipment under test. The red test prod with its small cord tip inserted into the +V — Ω —MA jack provides the remaining meter connection to the circuit being tested.

The 12 ampere direct current range is obtained between the COM-GND (negative) and 12A (positive) jacks.

The six positive and six negative (polarity determined by FUNCTION switch position) d.c. voltage ranges of 7.5, 30, 75, 300, 750 and 3000 volts are obtained between COM-GND (negative) and Vx2.5 (positive) jacks.

READING METER

The top scale is graduated directly in ohms from 0 to 2,000. The six RANGE knob positions yield six different resistance ranges differing only in the number of zeros to be added to the scale figures, the full-scale reading in each case being directly indicated by the RANGE knob figures.

The 3-volt a.c. range only is read on the scale immediately below the ohms figures.

All other voltage ranges, and direct current as well, are read on the green center scales. The graduations upon upper and lower green scales are identically spaced, the scales being linear. All voltage ranges beginning with the figure "3" are read upon the upper green scale, with appropriate number of zeros added as indicated by the RANGE switch setting. Similarly all ranges beginning with the figures "12" are read upon the lower green scale with appropriate zeros added.

When using the d.c. ranges beginning with the figures "7.5" provided by connecting the Vx2.5 panel jack, correct voltage is that indicated upon the upper green scale multiplied by 2.5, with appropriate zeros added. The high ranges so obtained but beginning with the figure "3" are read directly from the upper green scale with appropriate zeros added.

The decibel scale at the bottom of the meter scale is read directly, selecting the appropriate group of which the right-hand figure corresponds to the RANGE knob position. (For simplicity of meter face a small error has been intentionally allowed in the lowest db. range. This error corresponds to the difference in slope between the 3 V.AC meter scale and the upper green scale. It amounts to less than 2 db. from 0 to +10 db., and increases somewhat below 0 db., where the meter reads low.

PROPER USE OF TEST PRODS

A pair of insulated test prods accompany "VOMAX". One is conventional, black in color, and should **always** be plugged into the COM-GND jack. The second is red, and is of special design in that its circuit-contacting metal tip may be screwed into either end of the red prod sleeve. This tip must be inserted properly if serious error is to be avoided.

For all measurements except d.c. voltage screw the tip into the end nearest the point of rubber cord emergence.

For d.c. voltage measurement screw the tip into the far end of the red prod (the end furthest distant from the point of cord emergence).

This shift of red prod tip position allows one prod to do the work of two. When the tip is screwed into the cord end it connects directly to the cord, as for a.c. volts, ohms and ma. measurements. When the metal tip is screwed into the far end of the red prod a 1 megohm 1% resistor isolates it from the connecting cord, and so isolates the capacity of the instrument itself from any circuit under measurement. This permits measurement of d.c. operating voltages directly at the tube socket connections in an operating radio receiver without upsetting circuit behavior. Meter calibration is made at the factory with this 1 megohm resistor in the red prod in circuit upon d.c. voltage ranges, with it out of circuit on all other functions. If d.c. voltages are measured with the prod tip in the cord end of the red prod the meter will read 2% high.

INITIAL ADJUSTMENTS

Examine meter upon unpacking to make sure pointer reads exactly zero. If it does not, bring it to zero by adjusting the screw found on the meter housing at bottom center. If this mechanical zero-set operation is necessary, tap the meter as it is made to make sure that the pointer returns to exact zero after adjustment.

Insert mains plug into outlet providing 105/125 volts, 50/60 cycle a.c. power only. (For higher mains voltage see Page 1).

Turn ADJ. Ω knob just far enough to right from OFF to cause pilot light above this knob to light.

Allow two or three minutes for "VOMAX" tubes to warm up.

Set FUNCTION knob to +DC.

Set RANGE knob to 3V.

Set SET V-ZERO knob to bring meter pointer exactly to zero on the meter scale.

Rotate RANGE knob through all six positions and note insignificant change of meter zero reading. (ALWAYS ZERO METER ON 3 VOLT +DC. RANGE.)

Shift FUNCTION knob to DC— and note absence of zero shift as RANGE switch is rotated.

With zero established as above, set FUNCTION knob to Ω position RANGE to 2K Ω, and set ADJ. Ω knob to bring meter pointer exactly over 3.0 graduation on 3V AC scale. Rotate range knob and note absence of shift in meter reading.

Turn FUNCTION knob back to +DC, RANGE knob to 3V, and note zero. If it has shifted due to failing to allow sufficient time for "VOMAX" tubes to attain proper operating temperature, reset zero with SET-V-ZERO knob. Now set FUNCTION knob to AC and note constancy of zero reading as RANGE switch is rotated through all ranges.

(NOTE — AC and DC meter zero readings will differ less than 2% when tubes are new and when AC balance resistor R42 is properly set, as when "VOMAX" leaves the factory. As tubes age AC and DC zero readings will tend to separate slightly. Until this difference becomes significant it may be ignored or may be compensated for by readjustment of SET-V-ZERO knob for AC. When it exceeds 2% proceed as follows: set zero on +DC, 3V RANGE, shift FUNCTION knob to AC, adjust R42 to bring meter pointer to zero.)

Now insert the red test lead into the +V —Ω —MA jack and observe the flickering meter reading obtained upon the 3V ranges, DC or AC. This is not an indication of meter instability, for in setting zero the meter was entirely stable — remained so until the red prod was inserted in +V —Ω —MA jack. This flickering reading as the red prod is handled, touched, or moved about is simply a proof both of the high input resistance and the high sensitivity of "VOMAX" — both sufficiently high to reveal electrostatic pickup upon the short test lead itself. Check this fact by inserting the tip of the red prod into the COM-GND jack, when meter pointer will fall to zero.

With FUNCTION knob set to AC, withdraw r.f. diode probe from its panel socket and note the absence of zero shift. Touch the probe tip with the finger and note the meter flicker — the measure of high input resistance and high sensitivity. Short-circuit the probe tip to its shell and observe how the meter pointer falls to zero.

D.C. VOLTAGE MEASUREMENTS

Set FUNCTION and RANGE knobs to appropriate settings and contact the black and red prod tips (tip in far end of red prod) to the source of voltage to be measured, black **always** to chassis or common circuit ground, red to "hot" or "high" side of circuit. If meter reads in wrong direction, shift FUNCTION knob from +DC to DC—, or vice versa.

Check protection of meter against overload burnout by applying anything up to 3000 volts to the test prods with RANGE switch set to 3V. (Do not leave overload on meter for any length of time, for meter can be injured by lengthy overload.)

Gain familiarity with operation of the high voltage Vx2.5 ranges by measuring some d.c. voltage as above, then remeasure it after shifting red prod lead to Vx2.5 jack, notice the 60% reduction in meter reading when so measured (60% low since meter reading must be multiplied by 2.5 to obtain correct voltage when reading any "3" RANGE on upper green scale; "3" meter scales are correct for "12" RANGES when using Vx2.5 jack).

A.C. VOLTAGE MEASUREMENTS

Proceed as above with R.F. PROBE in its panel socket, using red and black test prods (tip in cord end of red prod). If a radio receiver or audio amplifier is handy, note how "VOMAX" will measure not only a.c. mains voltages, but a.f. voltages present at grids and plates as well.

In measuring a.c. voltages on the 1200 V range, contact the test prod to such high voltage briefly and as infrequently as possible to avoid damaging overload upon the 6AL5 rectifier tube. This range has been

efficiently and usefully obtained at the expense of possible deterioration on the 6AL5 tube if it is used excessively.

R.F. VOLTAGE MEASUREMENTS

Withdraw R.F. PROBE from "VOMAX" and measure r.f. voltages present in a radio receiver tuned to a strong signal by contacting the probe tip to grid or plate while probe shell simultaneously contacts chassis ground.

Since the R.F. PROBE adds about 8 mmfd. to any circuit to which it is contacted, a true voltage measurement will require temporary retuning of the trimmer capacitor tuning the circuit being measured to offset this added capacity. Once the measurement has been made the trimmer may be retuned to its original setting (or proper setting if it has shifted over time) by contacting the R.F. PROBE to a following tube grid or plate and returning the upset trimmer to the point of greatest voltage reading on "VOMAX".

RESISTANCE MEASUREMENTS

Set FUNCTION knob to Ω, RANGE knob to appropriate range, set ADJ. Ω knob to full-scale meter reading (if not previously done after setting SET-V-ZERO knob in +DC, 3V positions) and contact test prods to resistance to be measured. Read resistance directly on top meter scale, adding appropriate zeros as determined by setting of RANGE knob.

(NOTE — In checking battery-operated, low-current tubes for filament continuity DO NOT use the 2K Ω range for this applies nearly 3 volts to such filaments and may burn them out. Use the 20K Ω range, or an even higher one. This will check continuity properly and avoid burnout of battery tubes.)

Use the 2K Ω range no more than necessary, since load on ohmmeter dry batteries is greatest upon this range.

Ohmmeter accuracy being greatest at mid-scale, most accurate resistance measurements will result when a range is used which yields a reading thereabouts. "VOMAX" has sufficient resistance ranges to usually make this convenient.

When measuring resistance below 1 ohm, allow for resistance of test leads by noting resistance reading when their tips are touched together, and subtract this value of resistance from the measured value of the resistor being measured.

INSULATION RESISTANCE MEASUREMENTS

The 2000 megohm range allows measurements of leakage in capacitors, transformers, cables and insulation generally which have heretofore been almost impossible to the service technician. This range may be greatly extended by the addition of an external source of d.c. voltage (a battery or a radio receiver power supply). To measure resistances above 1000 or 2000 megohms, first measure the voltage (using COM-GND and +V −Ω −MA jacks only) of the external d.c. source used and note same. Then upon a low range of "VOMAX", measure the voltage which may appear when the capacitor (or the insulator) is connected between the voltage source and the red test prod inserted in +V −Ω −MA jack. The resistance in megohms of the insulator (?) will be given by the formula

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{\text{Source voltage} - \text{series voltage}}{\text{series voltage}}$$

For example, suppose a source of 300 volts (read on +DC, 300V settings) and a series voltage of 1.2 volts (read on +DC, 3V settings with test specimen connected between red test prod and positive terminal of voltage source), then

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{300 - 1.2}{1.2} = 12{,}699 \text{ megohms}$$

DIRECT CURRENT MEASUREMENTS

Set FUNCTION knob to MA, RANGE knob to 12A, insert black test prod lead into COM-GND jack and red test lead into 12A jack. Pass current to be measured through test prods and note meter reading. If current is too low to deflect meter usefully, shift red prod to +V −Ω −MA jack and turn RANGE knob to left, one position at a time, until useful reading is obtained.

(NOTE — ALWAYS proceed as above in making current measurements. The meter has no protection against overload in current measurements. Starting with RANGE knob set to too low a range can result in immediate meter burn-out. It is better to start out in current measurement on the highest range and spend a few seconds reducing range to obtain final reading than to hurry things and ruin the entire instrument.)

DECIBEL MEASUREMENTS

Set FUNCTION knob to AC, RANGE knob to selected db. range, and contact black and red prods to a.f. power source to be measured.

NOTE: As a db. meter "VOMAX" contains its own d.c. isolating capacitor. Its impedance is so high as not to noticeably load any usual power amplifier output circuit. Such amplifier output circuit must be terminated in its own specified output impedance in the form of usual load such as a loud-speaker voice coil, or in a non-inductive resistor of resistance equal to amplifier output impedance.

"VOMAX" will indicate db. directly upon its meter scale when connected across a 600 ohm amplifier output upon the basis of 1 milliwatt =0 db. In most cases amplifier output will not be 600 ohms, but some lower value suitable for direct connection to a loud-speaker voice coil. To read db. correctly across impedances other than 600 ohms, ADD the db. figure below to the meter indication when measurements are made across the corresponding impedance.

OUTPUT IMPEDANCE	ADD DB.	OUTPUT IMPEDANCE	ADD DB.
600	0	30	13.0
500	1.08	25	13.8
400	1.3	20	14.7
300	3.0	16	15.7
250	3.8	10	17.7
200	4.7	8	18.75
150	6.0	6	20.0
125	6.8	5	20.8
100	7.7	4	21.7
70	9.33	2.5	23.8
50	10.8	2.0	24.7

Power output in watts may be determined as

$$\text{WATTS} = \frac{\text{Output Voltage Squared}}{\text{Load Impedance}}$$

For example, the measured voltage across an 8-ohm voice coil load is 2 volts.

$$\text{WATTS} = \frac{2^2}{8} = \frac{4}{8} = .5 \text{ watts}$$

POWER INPUT MEASUREMENT

"VOMAX" can be used as an a.c. (or r.f.) ammeter to determine approximate power input to a radio receiver, etc. This involves measurement of the a.c. voltage drop across a low resistance resistor connected in series with the mains input to the equipment drawing power. Such resistor should be of low resistance in order that only a volt or two at most out of 117 nominal input volts appears across it.

For example, 2 ohms placed in series with a receiver power input circuit shows a voltage drop measured across it of 1.1 volts,

$$I = \frac{E}{R} \quad \frac{1.1}{2} = .55 \text{ amperes}$$

Measure the voltage across the receiver mains input and finding it to be 115 volts for example, multiplying volts by amperes gives power input in watts

115 volts X .55 amperes =63.25 watts.

This would be true if the receiver were a pure resistive load. This is substantially true for an a.c./d.c. receiver. An a.c. receiver having a power transformer presents a reactive load, and the statement for power input is not therefore strictly true. It is close enough in most cases to yield a good approximation of power input in watts, however.

By the same method, substituting a series capacitor in an antenna lead, for example, r.f. current may be measured, and power computed if load impedance is known.

VISUAL DYNAMIC SIGNAL TRACING

Measurement of a.c. heater voltages and d.c. grid, cathode, screen and plate voltages is the first step in serious receiver servicing. Check of the supply voltages so measured against the set manufacturers circuit diagram test voltage chart will reveal deteriorated tubes, faulty resistors, capacitors, transformers, reactors and open- or short-circuits. In the majority of cases of trouble these measurements, made with such a high resistance meter as "VOMAX", will localize the trouble and allow immediate replacement of the faulty part. The high resistance of "VOMAX" on d.c. voltage measurements is of inestimable advantage in checking a.v.c. systems, wherein the development of leakage in an a.v.c. bypass capacitor cuts down the a.v.c. voltage on one or more tubes. Such faults can be rapidly located by "VOMAX" through direct measurement of a.v.c. voltage at each successive controlled grid. Measure questionable resistors, and leakage resistance of capacitors.

When the procedure above shows everything to be correct, but operation poor, dynamic signal tracing becomes the service technicians invaluable aid. Actually this is nothing more than the measurement of the received signal voltage itself at every grid and plate successively through the entire amplifying chain of tubes in a radio receiver. Obviously if amplifier tubes are actually amplifying the signal voltage will appear greater as the R.F.PROBE is moved along successively from antenna input to power amplifier plate, circuit by circuit.

Quantitative signal tracing involves application of a strong signal from a local broadcast station or signal generator to the receiver input and the measurement of this signal voltage across antenna and ground, then across first grid to ground. The increase or decrease in voltage is the direct measure of gain or loss of antenna transformer. The same process is repeated for every amplifying stage in the receiver. Each measure-

ment preferably includes a tube and coupling transformer, and is most easily made first at one grid, then at the immediately following grid. The gain or loss is the larger voltage observed divided by the smaller.

Because of the inescapable though small input capacitance of any vacuum-tube voltmeter R.F.PROBE, shunting the probe across grid to ground of an r.f. or i.f. stage adds capacity thereto — about 8 mmfd. in the case of "VOMAX" R.F.PROBE contacted directly tip to grid or plate and shell to chassis. This added capacity will slightly detune the circuit being measured and so reduce the voltage appearing across it at the instant of measurement. In preliminary qualitative tests this effect may often be ignored, but for precise measurements the trimmer of the circuit across which voltage is being measured should be adjusted, while the R.F.PROBE is contacted to the circuit, to give maximum voltage reading. The trimmer may be reset by moving the R.F.PROBE along to the next grid circuit and then readjusting the preceding circuit trimmer for greatest voltage reading.

In visual dynamic signal tracing as above the effect of the receivers a.v.c. system must be allowed for. When a strong signal is applied to the antenna input the a.v.c., if functioning properly reduces the gain of each stage enough to hold the i.f. input to the second detector substantially constant. To measure true stage gains the a.v.c. must be rendered inoperative by connecting a jumper from ground to the r.f./i.f. grid side of the first a.v.c. series filter resistor.

From the above it is apparent that a.v.c operation may be accurately checked, and curves plotted if desired, by contacting "VOMAX" R.F.PROBE to the second detector input, retuning the appropriate i.f. trimmer temporarily to give greatest voltage reading, and then reducing antenna input in progressive steps. Plotting a curve of second detector input voltage versus r.f. antenna input voltage gives a basic a.v.c. curve.

In preliminary visual dynamic signal tracing it is convenient to dispense with the necessity of retrimming each circuit measured when the R.F.PROBE is contacted to it. This is made possible by reducing the 8 mmfd. input capacitance of the R.F.PROBE to some value so low as not to necessitate retrimming. A capacitor of .5 to 1 mmfd. placed in series with the R.F.PROBE tip and the grid or plate to be contacted will reduce R.F.PROBE capacitance-loading to a value so low as not to significantly upset the tuning of the circuit being measured. Such a capacitance must be as small in physical size as possible. It is most easily obtained by cutting a length of spaghetti insulating tubing of size which will just slip over the R.F.PROBE tip to a length which will completely cover the tip.

This spaghetti sleeve acts as the dielectric of a small capacitor, the plates of which are formed by the R.F.PROBE tip and the socket lug against which the spaghetti (with tip inside it) is contacted. This is a most effective method of simplifying signal tracing. It reduces the sensitivity of the meter considerably, but the 1 volt obtainable from the average local broadcast station or signal generator will usually be sufficient to give a perceptable meter deflection at antenna, first r.f. grid, or certainly at second r.f. grid.

MISCELLANEOUS TESTS

OSCILLATOR VOLTAGE: The strength of oscillation of a superheterodyne or other oscillator may be measured directly in volts with "VOMAX". Contacting the R.F.PROBE to oscillator grid and ground will give a direct indication of the r.f. voltage being developed by the oscillator. It may also be estimated as the negative d.c. voltage developed at the oscillator grid, FUNCTION switch set to DC−, RANGE to appropriate voltage range, and tip in far end of red prod contacted to grid. The first method measures oscillator r.f. voltage directly, the second is indirect and less desirable. By the direct R.F.PROBE method uncertainty is eliminated. Oscillator voltages over each and every band of a receiver up beyond 100 megacycles may be so measured directly.

A.V.C. VOLTAGE: This important class of measurements has been covered under VISUAL DYNAMIC SIGNAL TRACING. A.v.c. voltages are usually negative with respect to chassis ground. FUNCTION knob should therefore be set to DC−, and red prod with tip in far end successively contacted to a.v.c. load resistor, then to each a.v.c.-controlled grid. A stable and reasonably strong input signal should be employed, as from a local broadcast station or signal generator. IT IS CONVENIENT TO CONNECT "VOMAX" ACROSS THE SECOND DETECTOR, OR A.V.C., LOAD RESISTOR IN ALIGNMENT — WHEN ALIGNMENT SHOULD BE EFFECTED TO GIVE GREATEST METER READING.

FM AND A.F.C. DISCRIMINATOR VOLTAGE: The d.c. voltage developed by the discriminator in FM receivers, and in a.f.c. systems, may be measured directly across the discriminator load resistors with "VOMAX". Because this voltage shifts from positive to negative as signal frequency is varied, a zero-center meter is desirable. When properly aligned to a carrier frequency, discriminator output should be zero. Use of a zero-left meter can indicate deviation in only one direction. "VOMAX" can be converted to a zero-center meter for discriminator voltage measurement by simply adjusting the SET V-ZERO knob to bring the meter pointer up to 0 on the db. scale, when deviations in both directions may be readily observed.

TELEVISION RECEIVER VOLTAGE MEASUREMENTS: All types of voltages in television receiver video and audio channels may be measured by "VOMAX". As a peak-reading a.c. voltmeter "VOMAX" is calibrated in R.M.S. values of the sine wave, or .707 of peak value. It may be employed to measure the peak values of sweep oscillator voltages and of saw-tooth or square-wave sources.

AUDIO VOLTAGES: With R.F.PROBE in panel socket, FUNCTION knob at AC and tip in near end of red prod, audio voltages throughout all successive circuits of an audio amplifier may be measured from 20 cycles on up. At high frequencies, and in resistance-capacitance coupled a.f. amplifiers, the effect of the 50 mmfd. input capacitance of "VOMAX" when so used must be allowed for. In making accurate measurements over a wide frequency range it is desirable to do so with the R.F.PROBE directly. However, the 500 mmfd. input capacitor in the R.F.PROBE is so small as to cause error at usual audio frequencies. This may be obviated if one lead from a capacitor of .025 to .1 mfd. is temporarily soldered to the small screw-head found on the R.F.PROBE ceramic head and the other lead of this capacitor used as the probe tip to the circuit under measurement.

SUPERIMPOSED VOLTAGES: D.C. voltages present in a circuit simultaneously with a.c. voltages, and vice versa, can be independently measured by "VOMAX" with no special precautions. When using a.c. functions the series input capacitor blocks out d.c. When using d.c. functions, the a.c. filter R41, C4 filters out a.c.

INSULATION RESISTANCE: Measurement of insulation resistance of capacitors, transformers, reactors and other insulators has been covered under INSULATION RESISTANCE MEASUREMENTS.

PRECAUTIONS: In order to keep input capacitance to a minimum in AC voltage functions of "VOMAX", and to similarly hold down input capacitance in DC operation, the red test lead has not been shielded. In making measurements on high resistance circuits, therefore, the red test lead should be kept away from a.c. mains conduits or wiring. In AC operation, grasp the red prod at its far end, vice versa in DC. Keep the red lead away from the body. Observation of these precautions, coupled with possible grounding of "VOMAX" panel in extreme cases of local electrostatic fields, will avoid errors due to same while keeping meter capacitance at a minimum.

CAPACITANCE MEASUREMENTS: Accurate capacitance measurement is possible only with a bridge circuit which takes into account both capacitance and resistance; which has a dissipation factor or power factor balance. The same is true for inductance measurements. However, rough but useful capacitance measurements may be made in an emergency with "VOMAX". What is so measured is the capacitance reactance, Cx, of the capacitor under test. The method involves connecting the unknown capacitor and a variable resistor in series across a source of 5 to 120 volts of 60 cycle a.c., and adjusting the resistor until the voltage measured across it equals exactly the voltage measured across the capacitor. The resistor is then measured upon the OHMMETER of "VOMAX" and its value located upon Fig. 4, from which point the capacitance may be read directly. One 3000 ohm rheostat and one 3 megohm rheostat will serve for capacitors between 10 and .01 mfd. (When using 50 cycles, true capacitance is ⅚ of the value so indicated.)

MAINTENANCE

Built of the highest quality parts to close to military standards of excellence, no trouble need be anticipated with "VOMAX" over long periods of time. Accuracy will be well maintained even though the same tubes are used in continuous operation for long periods of time. Variation in and aging of tube characteristics have little effect upon operation.

OHMMETER BATTERIES: Ohmmeter batteries should be replaced when they measure less than 2.2 volts total as measured by +DC FUNCTION, 3V RANGE of "VOMAX" itself or when OHMMETER readings become unstable. Connections to batteries should be unsoldered, old batteries removed, new ones inserted and connections thereto resoldered.

VACUUM TUBES: 6SN7GT Vacuum tubes may be replaced when SET V-ZERO knob will not bring meter pointer to zero, or when zero appears unstable even after 10 to 15 minutes warm-up time. Known-good tubes may be directly substituted for original tubes. The same applies to the 6AL5 R.F.PROBE tube. It should be replaced when no adjustment of R42 only will make AC zero coincident with DC zero. If the first replacement 6AL5 tried will not permit establishing AC zero coincident with DC zero through adjustment of R42 alone, a second tube should be tried. If no second tube is available, required coincidence of AC and DC zeros brought about through adjustment of R42 only may be obtained by interchanging the connections to lugs 2 and 7 at the R.F.PROBE tube socket.

CALIBRATION: Recalibration should practically never be necessary unless the instrument is abused, damaged or its internal RANGE SET resistor adjustments are tampered with. DC calibration may be affected by applying 2 or 3 volts of precisely known d.c. voltage (measured by an external precision laboratory-type meter standard) to the 3V, +DC range of "VOMAX" and then carefully adjusting R22 for identical readings between the external standard meter and "VOMAX" meter. Higher voltage ranges when tested will then be found to be in step.

AC calibration requires an equally good meter having ranges of 2/3, 8/12, 20/30 and 80/120 volts, together with a low-frequency a.c. voltage source within these limits. Having zeroed "VOMAX", calibration consists of applying a definitely known 50 or 60 cycle a.c. voltage to "VOMAX" input, and adjustment of internal a.c. RANGE SET resistors to identicality of meter readings for the four different a.c. voltages on the four meter ranges. Using an external voltage which will give a meter reading somewhere upon the upper ⅓rd of "VOMAX" scale for each of the 3, 12, 30 and 120 volt ranges, adjust the appropriate RANGE

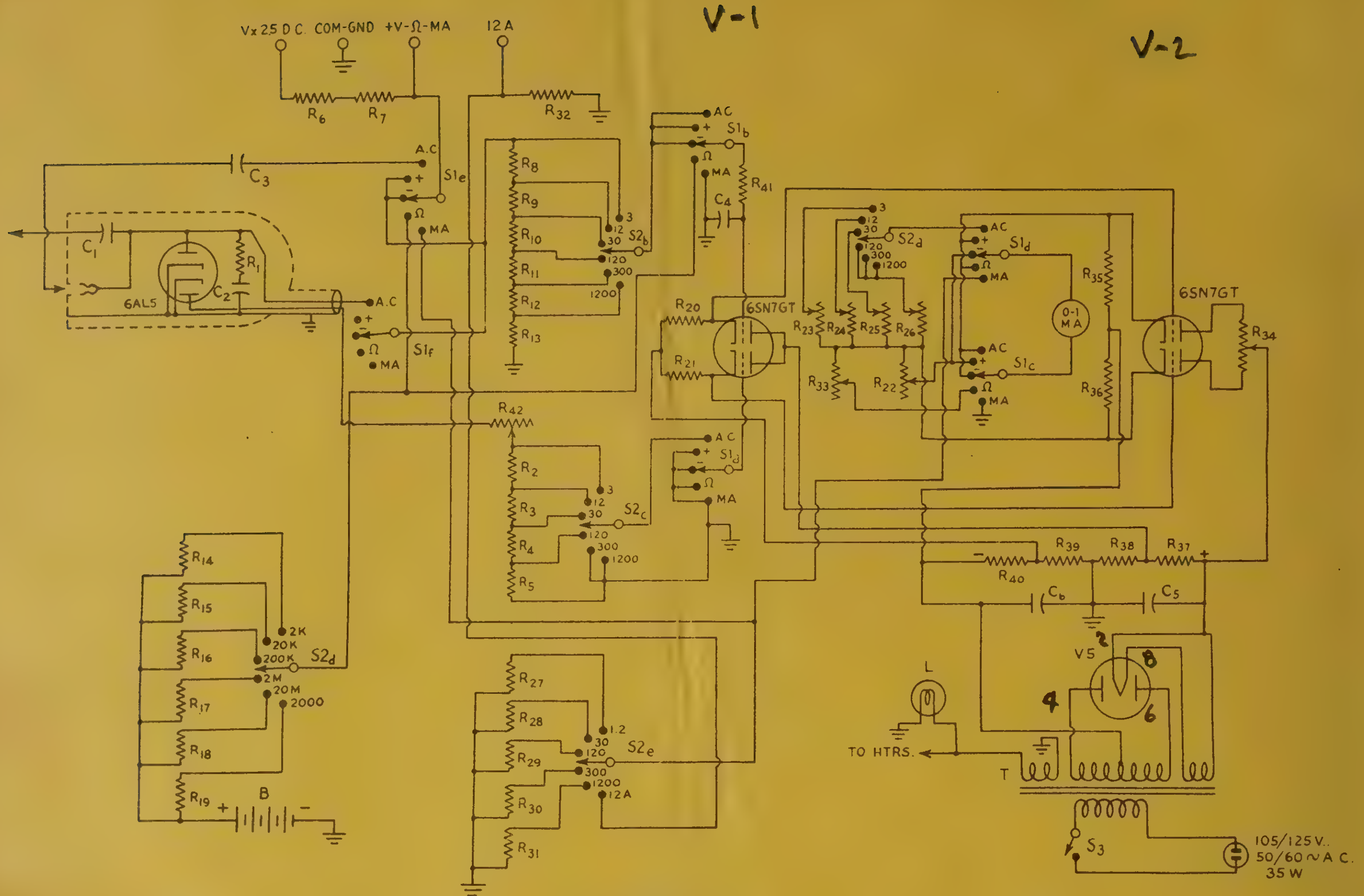


Figure 3

SET resistor for each of these ranges; R23 for 3 volt range, R24 for 12 volt, R25 for 30 volt and R26 for 120 volt range. Adjustment of R26 on the 120 volt range will bring 120, 300 and 1200 volt AC ranges into proper step.

TESTING "VOMAX": The chart appended to Fig. 3 gives voltages correct to 20% which should be observed when the red prod is contacted to the d.c. voltage points listed. Internal a.c. voltages may be similarly measured upon appropriate ranges of "VOMAX" by using both red and black prods to measure mains input voltage, and red prod only for 6.3 volt heater circuits and high voltage power transformer secondaries.

FILTER CAPACITORS: Electrolytic capacitors C5, C6 are polarized. Their + terminals must contact their + spring contactors. Reversal of C5, C6 polarity will ruin them and damage the power transformer and rectifier tube.

CAUTION: HIGH VOLTAGES ARE DEADLY. When measuring high voltages attach black test lead to one side of circuit to be measured, put one hand in pocket, stand on well insulated floor, and holding red test prod lightly between thumb and fore-finger at middle of red prod, contact its tip to high voltage point to be measured. DON'T TAKE CHANCES — YOU HAVE ONLY ONE LIFE — DON'T RISK LOSING IT.

CAUTION: To obtain the extremely useful 1200 volt AC range of "VOMAX" has necessitated operation of the 6AL5 rectifier beyond tube manufacturers' ratings. Extensive tests have revealed no evidence of premature tube deterioration. However, to insure long tube life use the 1200 volt AC range no more than absolutely necessary, and then only briefly. For example, contact prod to source to be measured, read meter, remove prod from source at once.

OPERATING VOLTAGE CHART

Cathode ends of R20, R21 to ground, +2 V d.c.
Cathode ends of R35, R36 to ground, +2 V d.c.
Cathode end of R39 to ground, −17 V d.c.
Cathode end of R40 to ground, −180 V d.c.
Plate end of R38 to ground, +17 V d.c.
Plate end of R37 to ground, +180 V d.c.
Heaters to ground, 6.3 V a.c. (at transformer)
Plates of 5Y3GT to center-tap (tube out of socket) 320 volts a.c.

PARTS LIST

C1 — 0.0005-ufd. silver-mica
C2 — 0.001-ufd. mica
C3 — 0.03-ufd. 3000-volt tubular oil
C4 — 0.005-ufd. mica
C5, C6 — 8-ufd. 350-volt electrolytic
R1 — 20-megohm, ±5 per cent, ¼-watt carbon resistor
R2, R9 — 7.5 megohms, ½ watt metalized resistors*
R3 — 1.5 megohms, ½ watt metalized resistors*
R4, R11 — 750,000 ohms, ½ watt metalized resistors*
R5 — 250,000 ohms ½ watt metalized resistors*
R6, R7, R8 — 37.5 megohms, — watt metalized resistors*
R10 — 3.75 megohms, ½ watt metalized resistors*
R12 — 375,000 ohms, ½ watt metalized resistors*
R13 — 125,000 ohms, ½ watt metalized resistors*
R14 — 10-ohm, 1 per cent ½ watt wire-wound
R15 — 100 ohms, ½ watt metalized resistors*
R16 — 1,000 ohms, ½ watt metalized resistors*
R17 — 10,000 ohms, ½ watt metalized resistors*
R18 — 100,000 ohms, ½ watt metalized resistors*
R19 — 10 megohms, ½ watt metalized resistors*
R20, R21, R41 — 5.1 megohm, ±5 per cent, ½ watt metalized resistor
R22, R23, R24, R25, R26 — 3000 ohm wire-wound potentiometer
R-27 — 258.4 ohm, 1 per cent wire-wound resistor
R28 — 1.758 ohm, 1 per cent wire-wound resistor
R29 — 0.423 ohm, 1 per cent wire wound resistor
R30 — 0.161 ohm, 1 per cent wire-wound resistor
R31 — 0.028 ohm, 1 per cent wire-wound resistor
R32 — Special-Set in test to give 12-ampere range
R33 — 10,000 ohm, wire-wound potentiometer with s.p.s.t. switch
R34 — 3000 ohm wire-wound potentiometer
R35, R36, R37, R40 — 43,000 ohms, ±5 per cent, 2 watt metalized resistors.
R38, R39 — 4,300 ohm, ±5 per cent, ½ watt metalized resistors.
R42 — 10 megohm potentiometer
S1 — 5-position, 6-circuit, 3-section ceramic switch
S2 — 5-circuit, 6-position, 5-section ceramic switch (front section shorting)
T — Power Transformer; 115-volt, 50/60 primary; 5-volts, 2 amp.; 6.3 volts, 1.6 amp.; 640 volts, 50 ma.
*Pairs of I.R.C. BT-½ resistors matched in series to give specified values.

Hook up Page 11

from

FLESHER CORP

FLESHER CORP
TU-170
SEND
REC
ON
OFF
0
.2
.4
.6
.8
1.0
DC MILLIAMPERES
AUTO-START
THRESHOLD
ON
OFF
AUTO

the TU-170

terminal unit

TU-170
RTTY Terminal Unit

Assembly Manual

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Introduction

In some instructions, you are to "prepare" a length of wire. In each case, cut the wire to the length specified, and strip 1/4" of insulation from each end. Tin each end and connect as instructed. For striped wires, white/blue means a white wire with a blue stripe.

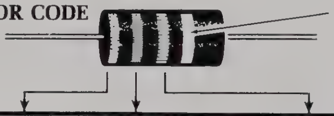
Soldering abbreviations are given in the steps. [NS] means not to solder because other wires will be added later. [S3] means to solder the connection. The number following the "S" tells how many wires are to be soldered at the connection.

Components which mount to the chassis are identified in the pictorial labled CHASSIS ASSEMBLY. The numbers beside each component indicate the numbering of their terminals. This pictorial is a view from above with the front and rear panels "unfolded". Connections to the components are identified with the component designation followed by the terminal number, such as SW2(3), meaning switch SW2, terminal number three.

Due to the small foil area around the circuit board holes and the small areas between conductor paths, it will be necessary to use upmost care to prevent solder bridges between adjacent foil areas. Use only a minimum amount of solder and do not use larger than a 25 watt soldering iron with a small tip, and apply heat only long enough to make a good solder connection.

In these instructions, the circuit board will be assembled first, then set aside while the cabinet components are mounted and wired. In the last series of steps, the circuit board will be wired into the cabinet. Alignment instructions follow final assembly.

RESISTOR COLOR CODE



TOLERANCE
Gold 5%
Silver 10%
No Band 20%

COLOR	1st DIGIT	2nd DIGIT	MULTIPLY BY
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	1,000,000,000
GOLD			.1
SILVER			.01

Circuit Board Assembly

Use the component location drawing and the parts list (page 12 & 13) to assemble the circuit board. Follow the sequence below for easy assembly.

(✓) Install all jumper wires on the board. (There are 8.)

(✓) Install all diodes.

(✓) Install all resistors except R58, R59, ~~and R74~~

(✓) Install resistors R58, R59, ~~and R74~~

(✓) Verify that all resistors all installed correctly.

(✓) Install all integrated circuits except IC9, and IC10.

( ) Install all trimmer potentiometers.

(✓) Install all capacitors except C33, C34, and C35.

(✓) Install all transistors except Q6.

(✓) Mount the heatsink to the circuit board with the mounting tabs of the heatsink on the component side of the circuit board. Use #6 hardware.

(✓) Fasten the threaded spacers to the circuit board at the remaining two corner mounting holes. Use 4-40 by 1/4" screws.

(✓) Bend the leads of IC 10 so that the metal side will be flat against the heatsink when it is installed. Use a mylar insulator and #6 nylon hardware to mount the IC. Be careful not to over tighten the nylon hardware. Solder the IC leads to the board.

(✓) Bend the leads of IC9 in a similar manner, and install it just as IC10.

(✓) Bend the leads of Q6 in a similar manner, and install it using #4 nylon hardware and an insulator.

(✓) Install transformers T1 and T2.

(✓) Install capacitors C33, C34, and C35. Observe polarity.

(✓) Mount the lamp holder to the heatsink as shown with #6 hardware.

(✓) Prepare a 3" length of tan wire. Solder one end to circuit board terminal Y, and the other end to LH(1) [S1].

(✓) Prepare a 3 1/2" length of tan wire. Solder one end to circuit board terminal X, and the other end to LH(2) [S1].

(✓) Prepare a 4" length of white/blue wire. Solder one end to circuit board terminal G, and the other end to circuit board terminal P.

(✓) Prepare a 10 1/2" of white/blue wire. Solder one end to circuit board terminal N. Leave the other end free.

(✓) Prepare a 6" length of white wire. Solder one end to circuit board terminal L1. Leave the other end free.

(✓) Prepare a 5 1/2" length of black wire. Solder one end to circuit board terminal L2. Leave the other end free.

(✓) Prepare a 9" length of white/red wire. Solder one end to circuit board terminal R. Leave the other end free.

(✓) Prepare a 8" length of white/orange wire. Solder one end to circuit board terminal S. Leave the other end free.

(✓) Prepare a 7 1/2" length of orange wire. Solder one end to circuit board terminal T. Leave the other end free.

(✓) Prepare a 9 1/2" length of red wire. Solder one end to circuit board terminal U. Leave the other end free.

(✓) Prepare a 6" length of white/black wire. Solder one end to circuit board terminal G1. Leave the other end free.

(✓) Prepare a 7" length of white/yellow wire. Solder one end to circuit board terminal M. Leave the other end free.

(✓) Prepare a 5 1/2" length of pink wire. Solder one end to circuit board terminal L. Leave the other end free.

(✓) Prepare a 9 1/2" length of green wire. Solder one end to circuit board terminal A. Leave the other end free.

(✓) Prepare a 8 1/2" length of white/green wire. Solder one end to circuit board terminal B. Leave the other end free.

(✓) Prepare a 12 1/2" length of grey wire. Solder one end to circuit board terminal C. Leave the other end free.

(✓) Prepare a 6" length of brown wire. Solder one end to circuit board terminal D. Leave the other end free.

(✓) Prepare a 9 1/2" length of violet wire. Solder one end to circuit board terminal E. Leave the other end free.

(✓) Prepare a 10" length of light blue wire. Solder one end to circuit board terminal F. Leave the other end free.

(✓) Prepare a 15 1/2" length of white/violet wire. Solder one end to circuit board terminal J. Leave the other end free.

(✓) Prepare a 5" length of dark blue wire. Solder one end to circuit board terminal H. Leave the other end free.

(✓) Prepare a 5" length of tan wire. Solder one end to circuit board terminal K. Leave the other end free.

( ) Verify all connections and examine closely for solder bridges, poor connections, etc.

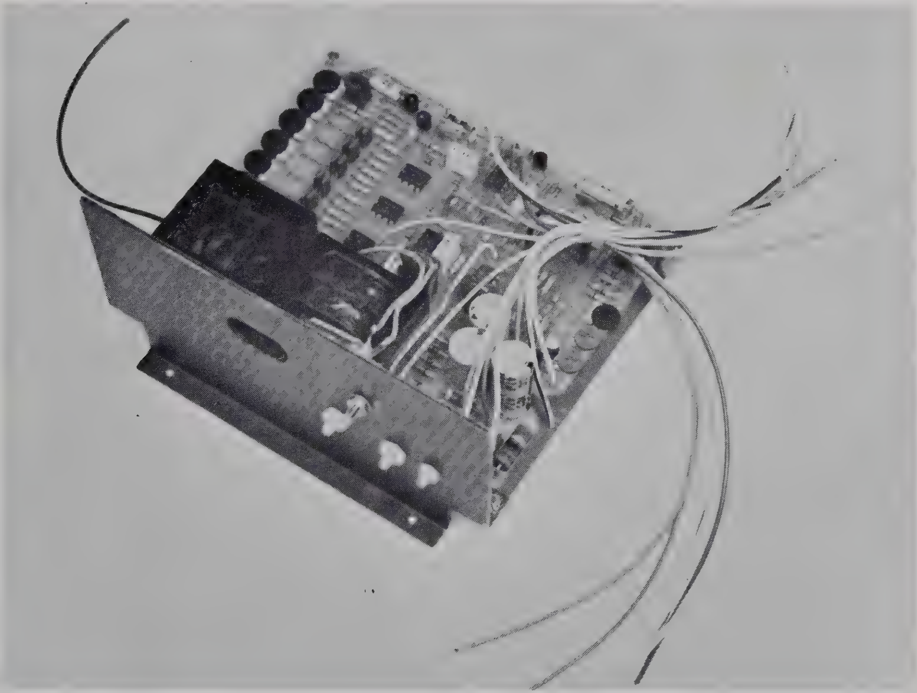
(✓) Route all of the free wires, except the white and the black wires, as shown in the photograph. Make sure the bundle of wires does not interfere in adjusting potentiometers P7, P8, and P9. Use a cable tie to secure the bundle.

(✓) Separate the bundle of wires so that the following wires are routed toward the heatsink:

white/blue, violet, white/violet, grey

(✓) The remaining wires should be routed in the opposite direction.

(✓) This completes the wiring of the circuit board. Temporarily set the board aside.



Chassis Assembly

(✓) Refer to the CHASSIS ASSEMBLY drawing to locate the position of the parts to be installed on the chassis in the next few instructions.

(✓) Mount the two position rocker switch in location SW1.

(✓) Mount the paddle switch in location SW2.

(✓) Mount the three position rocker switch in location SW3.

(✓) Place the thick spacer supplied over the shaft of the panel mount potentiometer, and mount it in location P10.

( ) Rotate the shaft of P10 full counter-clockwise, and fasten the knob with the pointer in the 7 O'clock position.

(✓) Mount the fuse holder in position FU using #6 hardware.

(✓) Mount the three lug solder terminal in position TS. Use #6 hardware.

(✓) Mount the nine-lug screw terminal on the outside of the chassis. Use #6 hardware and use a ground lug under each nut.

(✓) Mount the five-pin socket as shown in position J1. Use #4 hardware with no lock washers.

(✓) Mount the single circuit 1/4" phone jack in the position J2. Use a flatwasher under the nut.

(✓) Mount the two circuit 1/4" phone jack in position J3. Use a flatwasher under the nut.

(✓) Mount the solid state relay in position SSR. Mount with the "output" terminals nearest the square cut-out. Use #4 hardware with lockwashers under the nuts.

(✓) Snap the auxilliary AC power receptical in the square hole with the black and white wires at the top.

(✓) Mount the meter using #4 hardware.

(✓) Cut a 1 1/2" length of bare wire and connect from TB(1) [S1] to GG1 [NS].

(✓) Cut another 1 1/2" length of bare wire and connect from TB(9) [S1] to GG2 [NS].

(✓) Prepare a 1 1/2" length of white/black wire and connect from SSR(2) [S1] to GG2 [S2]

(✓) Prepare a 2" length of white/black wire. Connect it from J1(1) [S1] to GG1 [NS].

(✓) Prepare a 8" length of white/black wire. Connect it from GG1 [NS] to P10(1) [NS].

(✓) Prepare a 4" length of white/black wire. Connect it from P10(1) [S2] to M(2) [S1].

(✓) Prepare a 7 1/2" length of white/blue wire. Connect it from SW2(3) [S1] to SW3(3) [NS].

(✓) Prepare a 15" length of brown wire. Connect it from SW2(6) [S1] to J1(4) [S1].

(✓) Prepare a 15" length of yellow wire. Connect it from SW2(5) [S1] to J1(3) [S1].

(✓) Prepare a 12" length of violet wire. Connect it from SW3(2) [S1] to SSR(1) [S1].

(✓) Prepare a 2 1/2" length of black wire. Connect it from SW1(3) [S1] to FU(1) [S1].

(✓) Prepare a 5 1/2" length of black wire. Connect it from SW1(2) [S1] to TS(1) [NS].

(✓) Prepare a 4" length of white wire. Connect it from TS(3) [NS] to SSR(3) [S1].

(✓) Install the line cord with the plastic strain relief. Use a pair of pliers to close the strain relief around the cord approximately 3" from the end. Press the strain relief and cord through the oval hole.

(✓) Connect the ribbed grey wire of the line cord to TS(3) [NS].

(✓) Connect the green wire of the line cord to TS(2) [NS].

(✓) Connect the remaining grey wire of the line cord to TS(1) [NS].

(✓) Cut the green wire from J4 to 3 1/3" length. Strip back 3/8" of insulation and tin with solder. Connect this wire to TS(2) [NS].

(✓) Cut the white wire from J4 to 2" length, and strip 3/8" of insulation from the end. Tin the wire with solder, and connect to SSR(4) [S1]

(✓) Cut the black wire from J4 to 4 1/2" length, and strip 3/8" of insulation from the end. Tin the wire, and connect it to FU(2) [NS].

(✓) Cut the leads of a .01 mfd, 1000 volt capacitor to 1/2". Connect one lead of the capacitor to TS(1) [S3], and the other to TS(2) [NS].

(✓) Cut the leads of another .01 mfd, 1000 volt capacitor to 1/2". Connect one lead to TS(2) [S4], and the other to TS(3) [NS].

(✓) Cut the leads of another .01 mfd, 1000 volt capacitor to 1/2". Connect one lead to J3(2) [S1], and the other to J3(1) [NS].

(✓) Refer to photo WIRING THE FRONT PANEL, and position the circuit board as shown.

(✓) Connect the white/blue wire from the circuit board to SW3(3) [S2].

(✓) Connect the violet wire from the circuit board to SW3(1) [S1].

(✓) Connect the light blue wire from the circuit board to P10(2) [S1].

(✓) Connect the grey wire from the circuit board to M(1) [S1].

(✓) Connect the white/violet from the circuit board to SW2(2) [S1].

(✓) Place the circuit board on the cabinet bottom and fasten it in place with the two #4 x 1/4" sheet metal screws at the front, and two 4-40 machine screws at the rear. Be sure no wires are pinched under the heatsink.

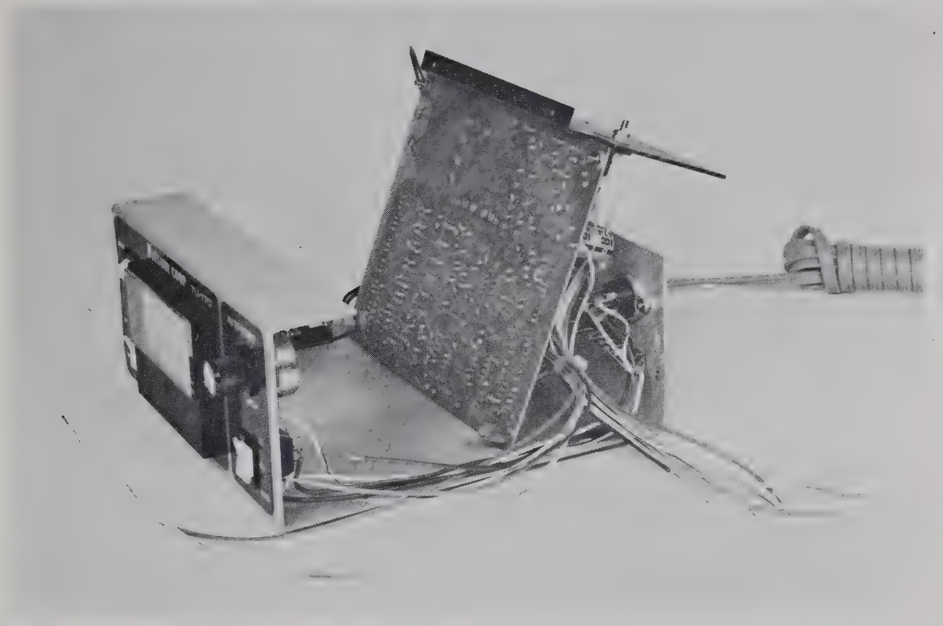
(✓) Connect the remaining wires from the circuit board as indicated:

(✓) white/black	to	GG1 [S4]
(✓) brown	to	TB(2) [S1]
(✓) dark blue	to	TB(3) [S1]
(✓) orange	to	TB(4) [S1]
(✓) white/orange	to	TB(5) [S1]
(✓) white/yellow	to	TB(6) [S1]
(✓) white/green	to	TB(7) [S1]
(✓) green	to	TB(8) [S1]
(✓) pink	to	J1(2) [S1]
(✓) tan	to	J2(1) [S1]
(✓) red	to	J3(3) [S1]
(✓) white/red	to	J3(1) [S2]
(✓) black	to	FU(2) [S2]
(✓) white	to	TS(3) [S4]

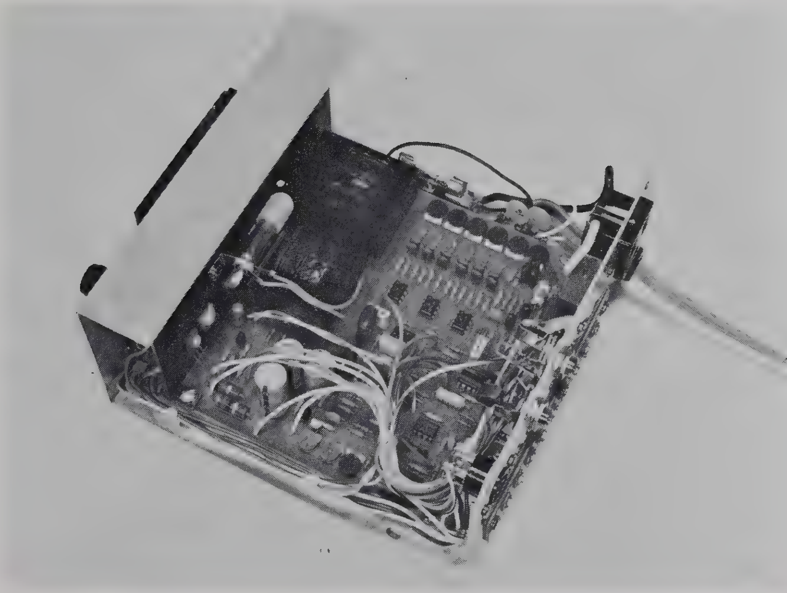
( ) Use the remaining cable ties to neatly bundle the wires. (Refer to the photo.)

(✓) Install the 3 amp fuse.

(✓) Install the 28 volt pilot lamp in its socket. Slip the white rubber diffuser over the bulb.



WIRING THE FRONT PANEL



COMPLETED WIRING

Alignment

(✓) Inspect all wiring. Make sure all connections are soldered properly and there are no shorts.

(✓) Plug the TU-170 into a 115 VAC, 60 Hz. outlet and turn the power switch on. The pilot lamp should light.

(✓) Connect a frequency counter to pin 2 of J1. Connect the frequency counter ground to the chassis of the TU-170.

(✓) Temporarily connect a jumper wire from SW3(3) to TB(6)

(✓) Adjust P8 for a frequency reading of 2125 Hz.

( ) Remove the temporary jumper from TB(6).

( ) Adjust P7 for a frequency of 2295 Hz.

( ) Connect an oscilloscope or AC voltmeter to J1(2).

( ) Alternately connect and disconnect the jumper from SW3(3) to TB(6), and adjust P9 until there is no difference in the amplitude of the output signal as seen on the oscilloscope or voltmeter.

( ) Connect a temporary jumper between J1(2) and TB(2).

( ) Set P1, P2, P3, P4, P5, and P6 to mid-rotation.

( ) Connect the temporary jumper from SW3(3) to TB(6).

( ) Adjust P1, P2, and P3 for maximum deflection of the tuning meter.

( ) Disconnect the temporary jumper from TB(6).

( ) Adjust P4, P5, and P6 for maximum deflection of the tuning meter.

( ) Remove all temporary jumpers and test equipment.

( ) Fasten the side panels in place with #4 sheet metal screws. Slide the cabinet top in place from the rear and secure with #4 sheet metal screws.

( ) Install the rubber feet on the bottom of the chassis.

( ) Use the short links supplied to jumper TB(3) to TB(4) and TB(5) to TB(6).

Station Connections

TRANSMITTER: Make up a short cord to connect the TU-170 to your transmitter. Use three conductor shielded wire and the 4 pin plug supplied. Connect pin 1 to the shield. Pin 2 is the audio output and will connect to your transmitter microphone input. Pins 3 and 4 are to connect to your transmitter push-to-talk connections.

RECEIVER: Connect the TU-170 to your receiver speaker connections, or the headphone jack. The connections should be made with shielded wire, with the shield connected to pin 1 of the screw terminal strip on the rear apron (ground) The audio connection is made on terminal 2.

If no other accessory equipment is to be used with the TU-170, use the two jumper straps supplied to jumper the "DEMOD. OUTPUT" (terminal 3) to "LOOP KEYING" (terminal 4), and the "LOOP MONITOR" (terminal 5) to "AFSK KEYING" (terminal 6).

TUNING OSCILLOSCOPE: If a tuning oscilloscope is to be used, connections are provided on terminals 7,8, and 9. The output level is approximately 15 volts peak-to-peak for each channel. Connect "SCOPE MARK" to the scope horizontal channel, and the "SCOPE SPACE" to the scope vertical channel.

CW KEY: A CW key may be used for approximately 100 Hz shift identification by plugging it into the "CW KEY" jack on the rear apron.

PRINTER: Use the three conductor (tip, ring, sleeve) jack supplied to connect the TU-170 to your printer. The positive loop connection is the jack tip, and the negative connection is the ring. The sleeve should be connected to the printer ground. Note: most printers will not operate if the loop polarity is reversed. The printer selector magnets should be set for 60 ma loop current, and the keyboard contacts should be in series with the magnets.

For autostart operation, the printer power cord may be plugged into the accessory outlet on the rear apron of the TU-170.

Make sure all equipment is properly grounded to a good earth ground to prevent transmitted RF from interfering with proper operation of the terminal unit.

OTHER EQUIPMENT: If other equipment is to be interfaced with the TU-170, such as a microprocessor, speed converter, etc., TTL compatible outputs are available on the terminal strip on the rear apron. Their operating description follows:

TERMINAL	DESCRIPTION
DEMOD. OUTPUT	TTL output from the demodulator. Output will drive one standard TTL load. "Mark" is high, "Space" is low.
LOOP KEYING	TTL input to key the loop. Mark is high, "Space" is low.
LOOP MONITOR	TTL output monitors loop current. "Mark" is high, "Space" is low.
AFSK KEYING	TTL input for keying audio frequency shift oscillator. Mark (2125 Hz) is high, "Space" (2295 Hz) is low.

NOTE: When no auxilliary equipment is being used, the DEMOD OUTPUT should be jumpered to LOOP KEYING, and the LOOP MONITOR should be jumpered to AFSK KEYING.

Parts List

OK on CAPACITORS

CAPACITORS

C1	.1 mfd (12V 104Z)
C2	.1 mfd (12V 104Z)
C3	4.7 mfd
C4	.1 mfd (12V 104Z)
C5	.05 mfd mylar (100V 503K)
C6	.05 mfd mylar (100V 503K)
C7	.005 mfd mylar
C8	" "
C9	" "
C10	" "
C11	" "
C12	" "
C13	" "
C14	" "
C15	" "
C16	" "
C17	" "
C18	" "
C19	" "
C20	" "
C21	4.7 mfd
C22	.22 mfd mylar (50V 224K)
C23	~~.01 polyester~~ .005 mylar
C24	.22 mfd mylar (50V 224K)
C25	4.7 mfd
C26	.01 mfd polystyrene
C27	.001 mfd
C28	.01 mfd 25V disk
C29	.1 mfd
C30	.005 mfd mylar
C31	.005 mfd mylar
C32	.1 mfd (12V 104Z)
C33	47 mfd, 100V
C34	220 mfd, 25V
C35	220 mfd, 25V
C36	10 mfd, 15V
C37	10 mfd, 15V
C38	.01 mfd, 1000V
C39	.01 mfd, 1000V
C40	.01 mfd, 1000V

DIODES

OK on DIODES

D1	1N4148
D2	"
D3	"
D4	"
D5	"
D6	"
D7	"
D8	"
D9	"
D10	"
D11	"
D12	"
D13	"
D14	"
D15	"

D16	1N4003
D17	"
D18	"
D19	"
D20	"
D21	"

OK on DIODES

IC's

IC 1	MC1458CP1
IC 2	"
IC 3	"
IC 4	"
IC 5	"
IC 6	"
IC 7	"
IC 8	555 / MC1455
IC 9	MC7812
IC 10	MC7912

OK on IC's

POTS

P1	200 ohms
P2	"
P3	"
P4	"
P5	"
P6	"
P7	50K ohms
P8	10K ohms
P9	1K ohms
P10	50K ohms

NO on POTS

TRANSISTORS

Q1	2N4123
Q2	2N4123
Q3	2N4123
Q4	2N4123
Q5	2N4125
Q6	MJE340
Q7	2N4123
Q8	MPF111

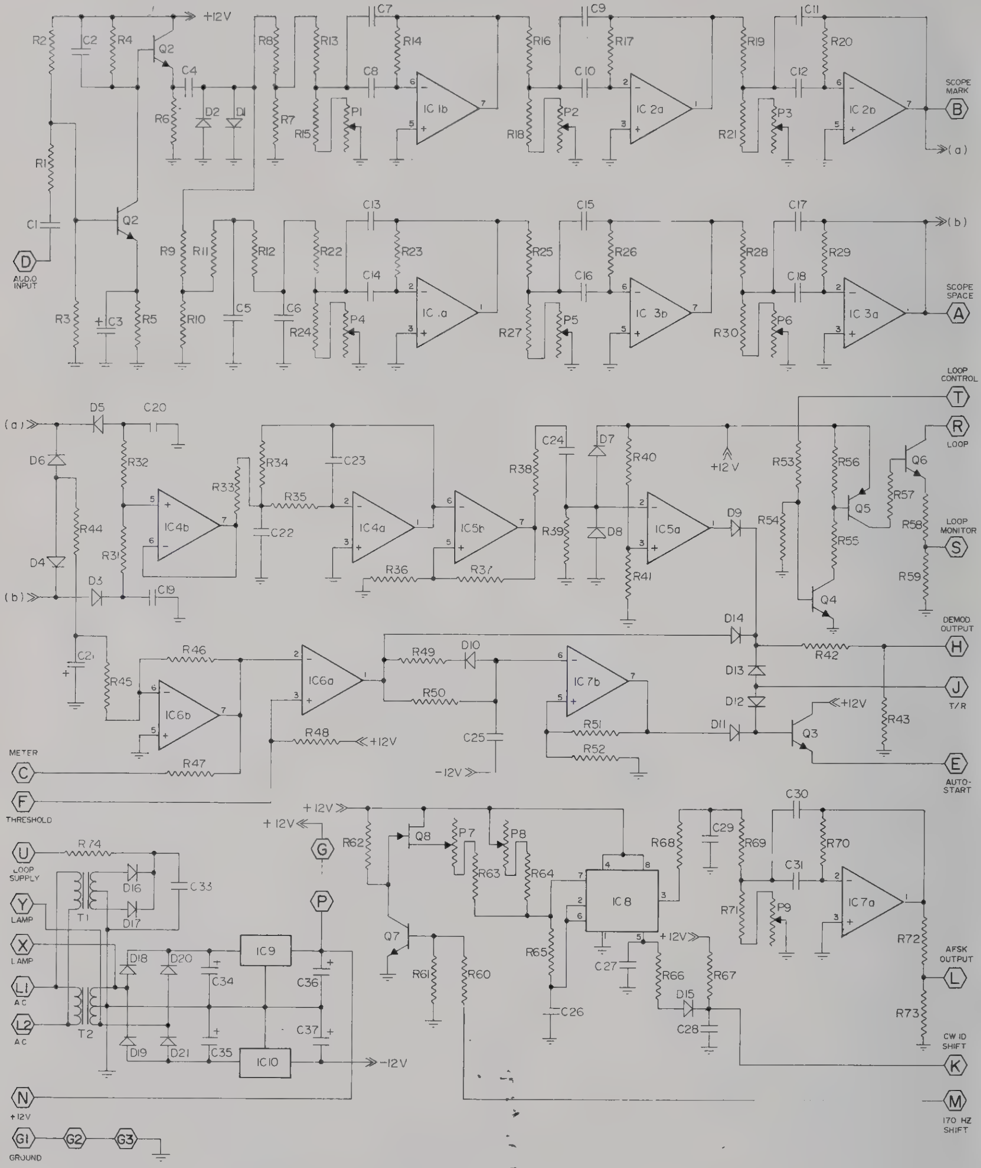
OK on TRANSISTORS

RESISTORS

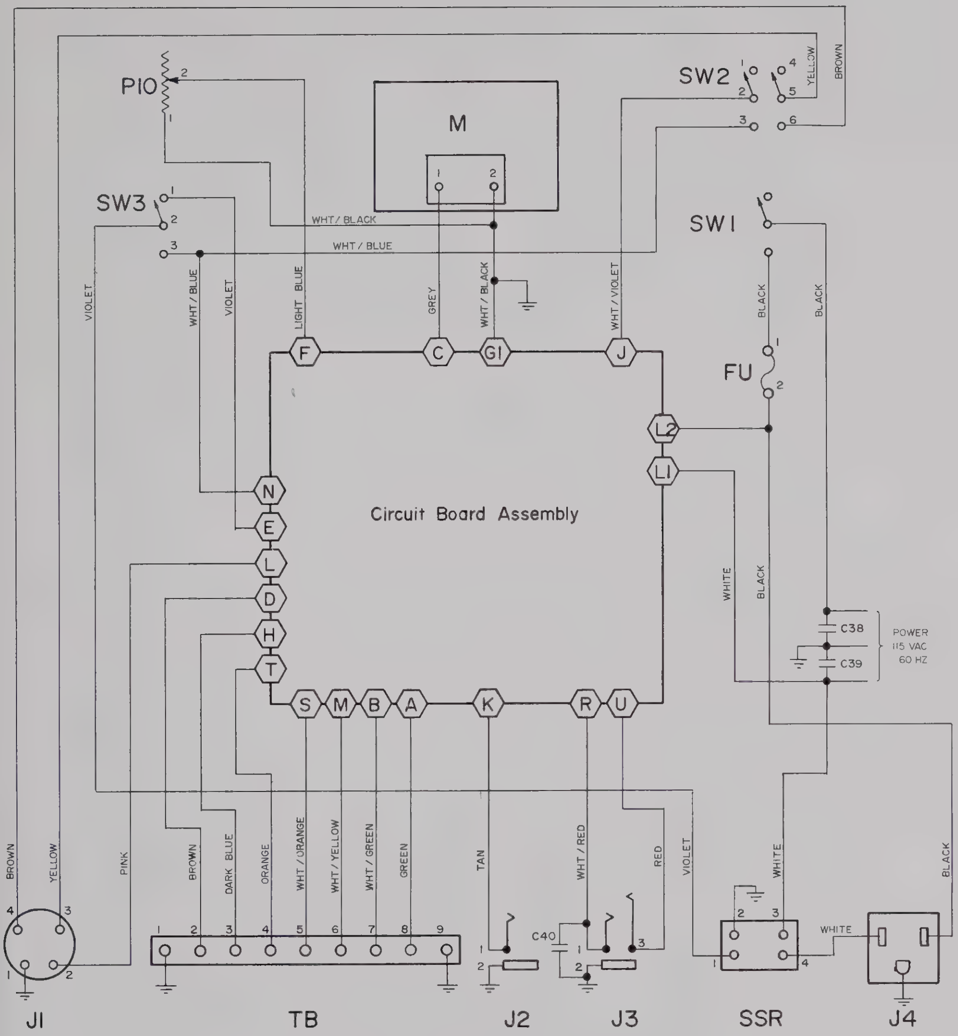
OK on RESISTORS

R1	330
R2	12K
R3	2.2K
R4	2.2K
R5	330
R6	1K
R7	560
R8	2.2K
R9	330
R10	1K
R11	1.8K
R12	1.5K
R13	39K
R14	390K
R15	470
R16	39K
R17	390K
R18	470
R19	39K
R20	390K
R21	470
R22	39K
R23	390K
R24	390
R25	39K
R26	390K
R27	390
R28	39K
R29	390K
R30	390
R31	100K
R32	100K
R33	390K
R34	390K
R35	24K
R36	2.2K
R37	12K
R38	2.2K
R39	390K
R40	39K
R41	3.9K
R42	1.5K
R43	1K
R44	2.2K
R45	100K
R46	100K
R47	8.2K
R48	39K
R49	100K
R50	390K
R51	3.9K
R52	12K
R53	2.2K
R54	2.2K
R55	2.2K
R56	2.2K
R57	1K
R58	100, 1W
R59	82, 1W
R60	2.2K
R61	2.2K
R62	39K
R63	24K
R64	10K
R65	27K
R66	100K
R67	2.2K
R68	10K
R69	15K
R70	150K
R71	1K
R72	10K
R73	1.5K
~~R74~~	~~47, 1/2 W~~

BK - 0
BN - 1
R - 2
O - 3
Y - 4
G - 5
BL - 6
V - 7
G - 8
W - 9


+12V
SCOPE MARK
B
(a)
(b)
SCOPE SPACE
A
D
AUDIO INPUT
LOOP CONTROL
T
R
LOOP
LOOP MONITOR
S
DEMOD OUTPUT
H
J
T/R
E
AUTO-START
METER
C
F
THRESHOLD
U
LOOP SUPPLY
Y
LAMP
X
LAMP
L1
AC
L2
AC
N
+12V
G1
G2
G3
GROUND
G
P
-12V
AFSK OUTPUT
L
CW ID SHIFT
K
M
170 HZ SHIFT
IC 1b
IC 2a
IC 2b
IC 3a
IC 3b
IC 4a
IC 4b
IC 5a
IC 5b
IC 6a
IC 6b
IC 7a
IC 7b
IC 8
IC 9
IC 10
Q2
Q3
Q4
Q5
Q6
Q7
Q8
T1
T2

Circuit Board Schematic


P10
SW2
YELLOW
BROWN
M
SW3
SW1
WHT / BLACK
WHT / BLUE
VIOLET
WHT / BLUE
VIOLET
LIGHT BLUE
GREY
WHT / BLACK
WHT / VIOLET
BLACK
BLACK
FU
F
C
G1
J
L2
L1
N
E
L
D
H
T
S
M
B
A
K
R
U
Circuit Board Assembly
WHITE
BLACK
C38
C39
POWER
115 VAC
60 HZ
BROWN
YELLOW
PINK
BROWN
DARK BLUE
ORANGE
WHT / ORANGE
WHT / YELLOW
WHT / GREEN
GREEN
TAN
WHT / RED
RED
VIOLET
WHITE
BLACK
WHITE
C40
J1
TB
J2
J3
SSR
J4

Chassis Wiring Diagram

Operating Instructions

FRONT PANEL CONTROLS

ON/OFF	Lower left switch turns on power to the terminal unit and the Autostart circuit.
ON/OFF/AUTO	Lower right switch controls autostart function. In the ON position, the auxilliary power outlet is turned on regardless of wether a teletype signal is present. In the OFF position the outlet is turned off regardless of wether a teletype signal is present. In the AUTO position the outlet is controled by the presence of a properly tuned teletype signal and upon the setting of the threshold control.
THRESHOLD	Upper right control sets the signal strength required to turn on the auxilliary power outlet when the function switch is in the AUTO position. Also sets signal strength required to allow the demodulator to key the 60 ma loop. Full counter-clockwise rotation allows the weakest signals to be printed.
SEND/REC	Upper left switch sets transmit/receive mode, and disables the demodulator output when in the SEND position.
METER	Indicates strength of filtered teletype signal.
TUNING	Proper tuning of your receiver requires that the mark tone be 2125 Hz, and the space tone be 2295 Hz. When properly tuned, the meter on the TU-170 will indicate nearly full scale, and be relatively steady. Some practice may be required to be able to tune in a station quickly. Start with the receiver volume at a normal listening level and slowly tune the receiver past a RTTY signal. Three peaks on the meter may be noticed. On one, the meter is steady, and on the other two peaks, the meter will quiver. The steady peak is the proper tuning. Adjust the receiver audio gain control downward until the meter starts to drop, then set the gain just a little louder. This is the proper input level setting. If the signal is fading in and out, set the audio gain high enough so that the meter will hold steady even as the signal varies in strength.

Detailed operating practices, and procedures are available in many amateur radio handbooks, and periodicals. (ie: ARRL Specialized Communications Techniques for the Radio Amateur.) The operator should familiarize himself with these, as well as applicable FCC rules and regulations before attempting to transmit RTTY signals.

FLESHER CORP

P.O. Box 976

Topeka, Ks. 66601

Instruction Manual

MODEL 711
Dynamic Test Set

International Communications Corporation
Miami, Florida

a milgo company

4405D7A/A 12/75

ICC welcomes your comments concerning this instruction book. Although every effort has been made to keep it free from errors, some do occasionally occur. When reporting a specific problem or error, please describe it briefly and include the instruction book part number, and the page number.

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1.0 GENERAL DESCRIPTION

The Model 711 Dynamic Test Set (Figure 1) ICC Part Number 4405-7A, permits a data technician or end user to test a synchronous modem by operating it in a simulated polled or point to point "hand shake" data transfer environment. Four test modes; ac loopback (local line loopback), 2-wire, 4-wire, and 4-wire multidrop, enable the Model 711 to perform excellent diagnostic tests on the modem.

The test set uses CMOS (low power) logic throughout its design. A low level of power consumption enables the test set to obtain power from the test voltages available at the modem's customer interface connector (25-pin J1) and therefore eliminates the need for an internal power supply in the test set.

Low power logic, high density packaging, and the elimination of a power supply enables this test set to be a small, lightweight, conveniently sized test device.

1.1 FUNCTIONAL DESCRIPTION

Figure 2 shows a simplified functional block diagram of the Model 711 Dynamic Test Set. Figure 5 (Page 12/13) provides a system timing diagram showing the interrelation of the test set to the system.

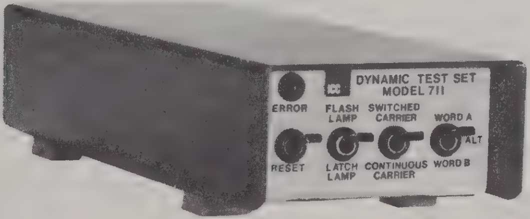

Figure 1: Model 711 Dynamic Test Set

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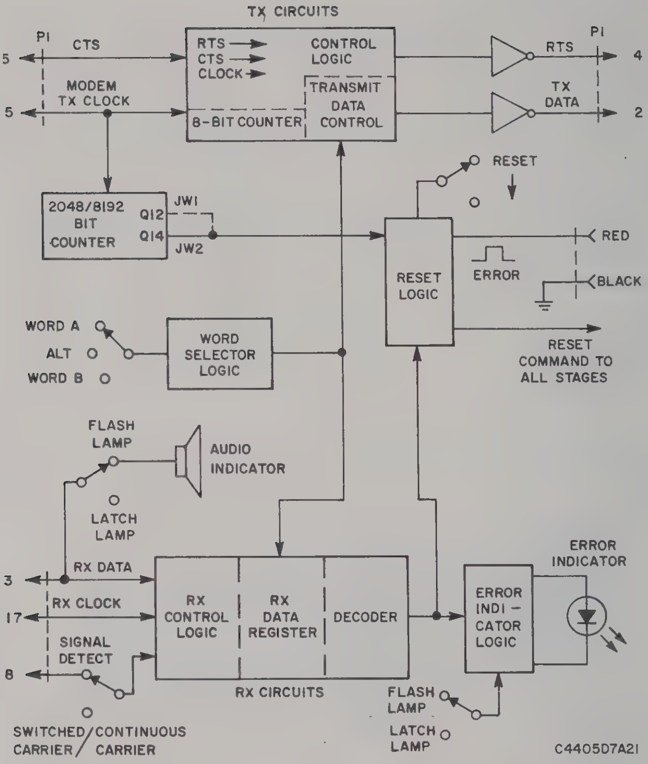

TX CIRCUITS
P1
CTS
5
MODEM
TX CLOCK
5
RTS
CTS
CLOCK
CONTROL
LOGIC
TRANSMIT
DATA
CONTROL
8-BIT COUNTER
P1
RTS
4
TX
DATA
2
2048/8192
BIT
COUNTER
Q12
Q14
JW1
JW2
RESET
RESET
LOGIC
RED
ERROR
BLACK
RESET
COMMAND TO
ALL STAGES
WORD A
ALT
WORD B
WORD
SELECTOR
LOGIC
FLASH
LAMP
AUDIO
INDICATOR
LATCH
LAMP
ERROR
INDICATOR
3
RX DATA
17
RX CLOCK
SIGNAL
DETECT
8
RX
CONTROL
LOGIC
RX
DATA
REGISTER
DECODER
ERROR
INDI-
CATOR
LOGIC
RX CIRCUITS
FLASH
LAMP
LATCH
LAMP
SWITCHED/CONTINUOUS
CARRIER/ CARRIER
C4405D7A21

Figure 2: Simplified Block Diagram, Model 711

The transmit circuits begin the testing by first raising the RTS (pin 4 of EIA interface) signal to the modem and then waiting for the modem to respond by raising the CTS (pin 5 of EIA interface) signal to the test set. Immediately after the CTS signal is raised, the test set sends an 8-bit test word on the Transmitted Data (pin 2 of EIA interface) lead to the modem. After the eighth bit is sent, the test set drops RTS.

The word selector switch and logic determine the 8-bit word pattern used by the transmit and receive circuits for comparative testing.

The receiving section of the Model 711 looks for a valid eight (8) bit test word on the Received Data (pin 3 of EIA interface) lead. This test word must be received within a given time-out interval.

Once the receiving section of the test set is enabled to look for a valid 8 bit test word, the word detector keeps looking for the valid test word until detected or the selected time-out ends. This enables the test set to ignore and not be affected by an echo or noise burst causing invalid bits which may be received preceeding the valid 8 bit test word.

NOTE

> If the carrier switch on the Model 711 is in the SWITCHED CARRIER position, the Model 711 does not raise its RTS signal until it detects the SIGNAL DETECT (pin 8 of EIA interface) lead switching to OFF.
>
> If the switch is in the CONTINUOUS CARRIER position, the Model 711 raises RTS immediately after a correct 8-bit test word is detected.

If the Model 711 does not detect the correct test word within a given time interval (Table 1), the ERROR lamp goes ON, the test set then raises its RTS signal, and initiates a new transmit sequence.

The delay time interval is determined by the 8192/(2048) time interval bit counter. Depending upon the Transmit Clock bit rate and the solder strap position, the delay interval may be determined from Table 1. The 8192 (standard) time delay interval is needed if the transmission circuit between 2 modems is a satellite circuit, particularly at 9600 bps.

Factory strapping is set up for ÷ 8192 counter; however, if the ÷ 2048 counter is desired, simply remove JW2 and insert a similar jumper wire in position JW1.

The reset circuits are controlled by either the reset switch or the delay time interval elapsing before a valid test word is detected by the test set.

While the RESET switch on the test set is held in the RESET position, the RTS signal is forced OFF, TX DATA is forced to MARK, and the ERROR indicator is extinguished.

When the RESET switch is released, RTS is raised and a new transmit sequence is initiated.

Table 1: Delay Time Intervals

Bit Rate	**8192 (F)**	**2048 (Solder Strap)**
2000	4.10 Sec.	1.02 Sec.
2400	3.41 Sec.	0.85 Sec.
3600	2.28 Sec.	0.57 Sec.
4800	1.71 Sec.	0.43 Sec.
7200	1.14 Sec.	0.28 Sec.
9600	0.85 Sec.	0.21 Sec.
(F) Factory Strapped		

1.2 PHYSICAL DESCRIPTION

The Model 711 logic components are mounted on a single printed circuit board. The controls and indicators and system cable are mounted on a single lightweight metal frame.

The weight and dimensions are:

Weight	17 ounces (481.95 gm)
Height	1.85 inches (4.12 cm)
Width	3.13 inches (8.00 cm)
Depth	8.06 inches (20.57 cm)
Cable Length	2 feet (60.96 cm)

1.3 SPECIFICATIONS

When properly connected and operated as described in paragraphs 2.4 and 3.0 of this manual, the Model 711 meets the following specifications.

1.3.1 Operating and Storage Environment

Ambient Temperature	-30°C to +60°C
Storage Temperature	-40°C to +85°C
Relative Humidity	0 to 95% noncondensing
Altitude	0 to 10,000 feet (3048 m)

1.3.2 Power Requirements

+V	+6V to +12V, +6mA typical, +60mA max. Less than 200mV RMS ripple.
-V	-6V to -12V, -6mA typical, -60mA max. Less than 200mV RMS ripple.
Power Dissipation	0.2 watts typical, 2.0 watts max. power supplied by modem.

NOTE

External power supplies may be used if power supply test voltages are absent from J1-9 and J1-10 of the modem's DTE interface connector. These supplies must be capable of delivering ±6V to ±12V with respect to signal ground. Any higher level supply voltages must be current limited so as not to deliver more than ±60mA to P1-9 or P1-10 with less than 200mV RMS ripple.

2.0 INSTALLATION

The 711 Dynamic Test Set does not require any special installation instructions. This device is meant to be used as a portable, hand-held, test device.

2.1 UNPACKING

Remove the test set from its shipping carton by first removing the plastic foam package from the carton. Remove plastic foam from around the test set and take special care to remove all shipping debris from the connector and the front of the test set. Examine the unit for any signs of shipping damage (e.g. broken switch handles). Be particularly thorough in this examination if the shipping carton shows punctures or signs of rough handling. Exercise all switches to ensure good mechanical operation. Save the shipping carton and packing material for reuse in case the unit is to be returned to factory.

2.2 MECHANICAL ASSEMBLY

The Model 711 Test Set does not require any special pre-connection assembly; however, if a solder strap change is to be made (i.e. to select the time delay period desired - see Table 1), the following procedure should be used:

(1) Remove four screws from bottom of test set.

(2) Slide cover to rear to remove. (This exposes the printed circuit board).

(3) Make the necessary strap change.

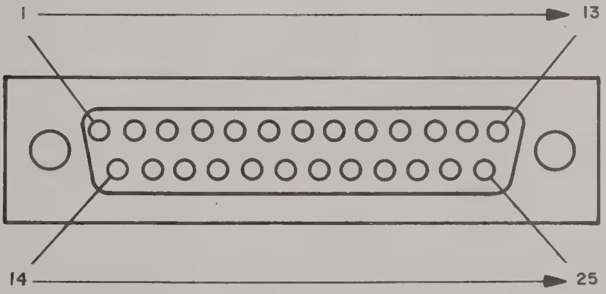
To replace the cover reverse the procedure.

2.3 SYSTEM CONNECTIONS

Connect the test set male connector to the J1 connector on the modem, in place of the customer's DTE interface cable. This connection supplies the necessary interface signals to the proper pins. See Figure 3 and Table 2 for connector pin convention and pin assignment. Paragraph 2.4 explains the system interface.

NOTE

All power required by this test set is supplied by the modem on this cable.



25 - PIN MALE CONNECTOR, PIN NUMBERING CONVENTION.

A4404D65A25

Figure 3: J-1 Pin Numbering Convention

Table 2: Interface Signals

P1 PIN	CIRCUIT, RS-232-C (CCITT)	SIGNAL	DIRECTION	FUNCTION
1	AA (101)	PROTECTIVE GROUND	INPUT	Chassis ground. Also connected to signal ground through a removable jumper wire.
2	BA (103)	TRANSMITTED DATA	OUTPUT	Serial synchronous binary data sent from the test set to the modem. MARK = -5.6V, SPACE = +5.6V.
3	BB (104)	RECEIVED DATA	INPUT	Serial, synchronous binary data sent from the modem to the test set. MARK = -5V to -25V. SPACE = +5V to +25V.
4	CA (105)	RTS	OUTPUT	Request to Send signal from the test set to the modem. ON = +5.6V, OFF = -5.6V.
5	CB (106)	CTS	INPUT	Clear to Send signal from the modem to the test set. ON = +5V to +25V, OFF = -5V to -25V.

Table 2: Interface Signals (continued)

P1 PIN	CIRCUIT RS-232-C (CCITT)	SIGNAL	DIRECTION	FUNCTION
7	AB (102)	SIGNAL GROUND	INPUT	Signal ground is the common ground reference for all signals except for protective ground.
8	CF (109)	RECEIVE LINE SIGNAL DETECT	INPUT	Carrier on signal from the modem to the test set. ON = +5V to +25V, OFF = -5V to -25V.
9	—	+V	INPUT	+6V to +12V, +6mA min, +60mA max.
10	—	-V	INPUT	-6V to -12V, -6mA min, -60mA max.
15	DB (114)	MODEM TX CLOCK	INPUT	Transmitter signal element timing information sent from the modem to the test set.
17	DD (115)	RX CLOCK	INPUT	Receiver signal element timing information sent from the modem to the test set.

Table 2: Interface Signals (continued)

P1 PIN	CIRCUIT RS-232-C (CCITT)	SIGNAL	DIRECTION	FUNCTION
20	CD (108.2)	DTR	OUTPUT	Data Terminal Ready signal from the test set to the modem. Direct connection to +V on pin 9.

Note: Pins number 6, 11 through 16, 18, 19, 21 through 25 not used.

2.4 INTERFACE SIGNALS

Table 2 lists the signals used by the Model 711 test set. These signals are compatible with RS-232-C logic levels.

NOTE

For all output signals, open circuit voltage is ±5.6V with a source impedance of 1200 ohms.
For all input signals, open circuit voltage may be ±5V to ±25V. Source impedance may be 0-5000 ohms.
For +V and -V inputs, open circuit voltages from ±6V - ±12V with a 0 ohm source impedance may be used. Any higher level supply voltages must be current limited so as not to deliver over ±60mA to P1-9 and P1-10.

NOTE

PROTECTIVE GROUND (P1-1) is connected to SIGNAL GROUND (P1-7) through JW-3 on the p.c. board. If it is necessary to separate these two grounds remove the solder strap at JW-3. See paragraph 2.2 for cover removal instructions.

3.0 OPERATION

Before operating the Model 711 Dynamic Test Set, the site operator should become familiar with all the controls and indicators and understand their functions.

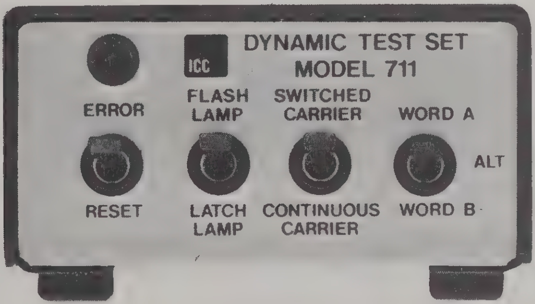
3.1 FRONT PANEL CONTROLS AND INDICATORS

The following is a brief functional decription of the controls and indicators shown in Figures 4 and 6.

NOTE

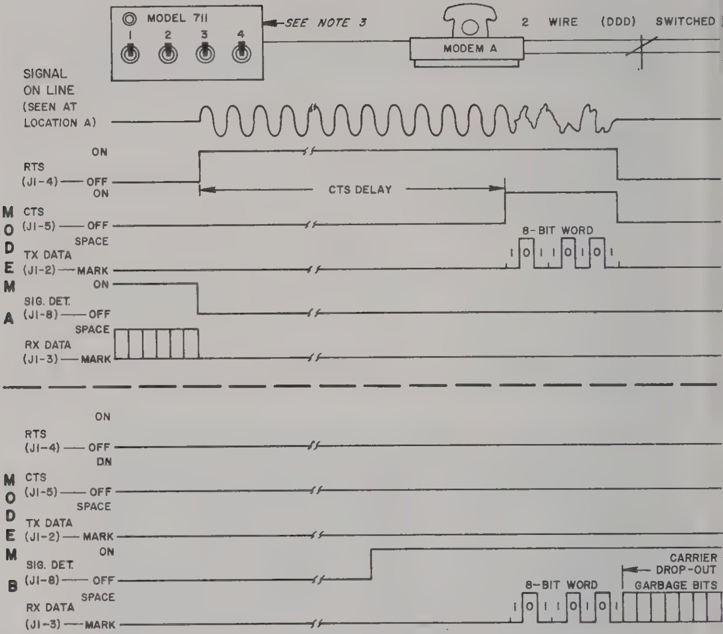
There are no controls or indicators on the rear of the test set; however, there are two test probe jacks available for pulse (event) counter connection.

Four control switches, an Error Lamp (LED type), two test probe jacks, and an audible indicator are provided on the Model 711.


ICC
DYNAMIC TEST SET
MODEL 711
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B

5D7A44122

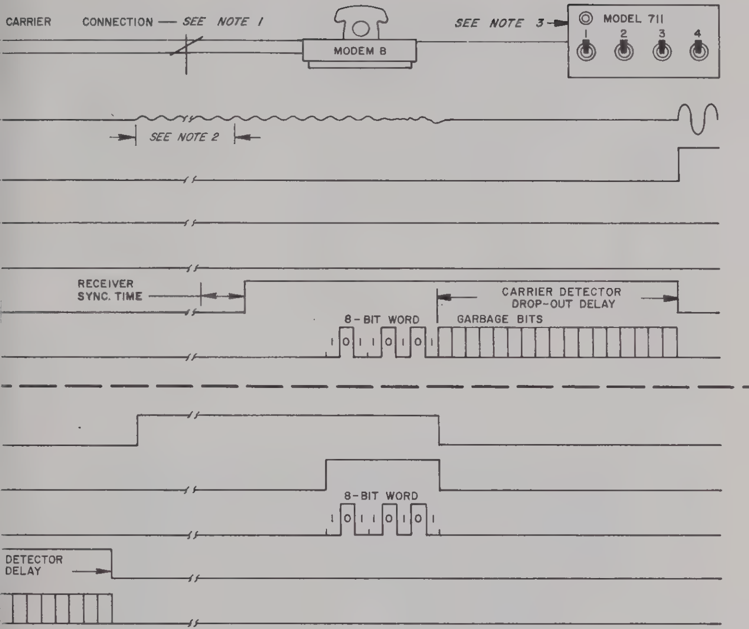
Figure 4 : Front Panel, Model 711


MODEL 711
1
2
3
4
SEE NOTE 3
MODEM A
2 WIRE (DDD) SWITCHED
SIGNAL ON LINE (SEEN AT LOCATION A)
MODEM A
RTS (J1-4)
ON
OFF
CTS DELAY
CTS (J1-5)
ON
OFF
8-BIT WORD
TX DATA (J1-2)
SPACE
MARK
1 0 1 1 0 1 0 1
SIG. DET. (J1-8)
ON
OFF
RX DATA (J1-3)
SPACE
MARK
MODEM B
RTS (J1-4)
ON
OFF
CTS (J1-5)
ON
OFF
TX DATA (J1-2)
SPACE
MARK
SIG. DET. (J1-8)
ON
OFF
RX DATA (J1-3)
SPACE
MARK
8-BIT WORD
1 0 1 1 0 1 0 1
CARRIER DROP-OUT
GARBAGE BITS

NOTES:

1. IN ANY DATA COMMUNICATIONS SYSTEM SUCH AS THIS, THE FOLLOWING CONDITIONS MUST BE SATISFIED
   1) CTS DELAY > RECEIVER ECHO DELAY.
   2) CTS DELAY > ECHO SUPPRESOR TURN AROUND DELAY + RECEIVER SYNC. TIME
2. THIS PORTION OF B'S TRANSMISSION MAY BE LOST DUE TO RECEIVER ECHO DELAY AND ECHO SUPPRESION TURN AROUND TIME.

Figure 5:. Syste


CARRIER
CONNECTION — SEE NOTE 1
MODEM B
SEE NOTE 3
MODEL 711
1
2
3
4
SEE NOTE 2
RECEIVER SYNC. TIME
CARRIER DETECTOR DROP-OUT DELAY
8-BIT WORD
GARBAGE BITS
1 0 1 1 0 1 0 1
8-BIT WORD
1 0 1 1 0 1 0 1
DETECTOR DELAY

3. MODEL 711 SWITCH POSITIONS:
   1) RESET – OFF
   2) FLASH LAMP/ LATCH LAMP – FLASH LAMP
   3) SWITCHED CARRIER/ CONTINUOUS CARRIER – SWITCHED CARRIER.
   4) WORD A / ALT / WORD B – WORD A.

D4405D7A22/A

Timing Diagram

Reset Switch - Depressing the RESET switch resets all of the internal circuits and extinguishes the ERROR lamp. While the RESET switch is depressed, RTS is held OFF, and the operation of the Model 711 is suspended. When the RESET switch is released, a new transmit sequence is automatically initiated.

Flash Lamp/Latch Lamp Switch - In the FLASH LAMP position, the ERROR lamp lights when an ERROR condition occurs and extinguishes when a valid 8-bit test word is again detected by the Model 711. In the FLASH LAMP position, the audio indicator is free to operate. It emits an audible sound whenever a logic "zero" (space) bit is detected on the received data lead.

In the LATCH LAMP position, the ERROR lamp lights when the decoder fails to receive a valid word within the delay time interval (see paragraph 1.1 and Table 1). The ERROR lamp remains lit until the RESET switch is depressed.

Audio Indicator - An audible annunciator (sonalert) within the test set emits a 3500 Hz tone whenever RX DATA is SPACE. When properly operating (RX DATA), the alternating marks and spaces create a "chirping" sound.

In the LATCH LAMP position, the audio indicator is disabled.

Switched Carrier/Continuous Carrier Switch - In the SWITCHED CARRIER position, the Model 711 observes the modem's SIGNAL DETECT output and operates as described in paragraph 1.1. In this operation, a valid received test word stops the received data register's clock (forces it high) until SIGNAL DETECT signal level falls. This holds the test set in a reset mode.

In the CONTINUOUS CARRIER position, the Model 711 ignores the SIGNAL DETECT signal output from the modem.

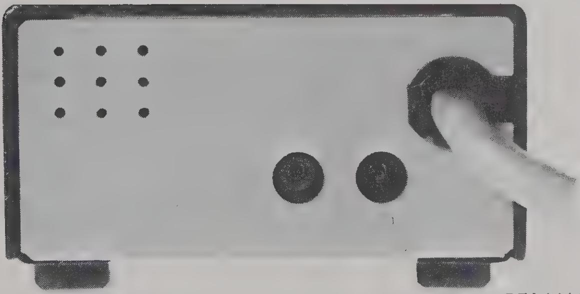
Word "A"/ALT/Word "B" Switch - This switch selects the word to be generated and recognized as valid by the Model 711. In the WORD A position, the Model 711 generates and decodes as valid TEST word A (10110101).

In the WORD B position, the Model 711 generates and decodes as valid TEST word B (11001101).

When in the ALTernate position, the Model 711 sends first Word A and waits for Word A to be received. Next, the Model 711 sends Word B and waits for Word B to be received. After receiving Word B the Model 711 test set repeats the procedure by again sending Word A. If either word is not received before the time-out ends, the Model 711 Test Set automatically initiates transmission of the next alternate word.

Error Lamp - The ERROR indicator, a light emitting diode, lights if a valid test word is not received before the time-out ends. The duration of this time out is factory selected to be 8192 bit intervals.

This time-out interval begins when RTS is raised. (Solder strap selection can be made to change this time-out duration to be only 2048 bit intervals - See Table 1).



5D7A44112

Figure 6: Rear Panel, Model 711

Rear Panel Error Test Probe Jacks - Two (2) test probe jacks are available on the rear of the test set for connecting an external pulse (event) counter. This enables automatic counting of the times a correct response was not received by the test set.

Both test jacks accept a 0.080" male pin plug. The black test jack is connected to 0V, the system ground return lead. The red test jack is normally at -5 Vdc when no errors are present, and will go to +5 Vdc for one bit period when an error condition exists. Since the source impedance of the error test jack signal is approximately 10K ohm, a counter with a high input impedance should be used for counting.

3.2 OPERATING PROCEDURES

The ICC Model 711 Dynamic Test Set is connected to the modem through the DTE (Customer Equipment/Business Machine) interface connector, J1, in place of the customer's equipment.

NOTE

> For testing only one modem, the modem under test must have Analog Loopback (AL) or Line Loopback test mode. On some WECo modem's this test can be performed if the modem is strapped for two wire, switched carrier service with "Local Copy" output enabled.

For testing over telephone lines, an ICC Model 711 test set must be connected to each modem. No more than two remote (polled) sites and the central (polling) site can be tested at one time in a multidrop system. The "Local Copy" option must be disabled on the data set during telephone line testing.

The following are the four most frequently encountered test configurations: (Figures 7, 8, 9, 10 & 11).

NOTE

For non-standard configurations not described in this text, contact ICC Customer Support for further detail and/or pertinent Application Notes

ANALOG LOOPBACK (SINGLE MODEM) Figure 7

This configuration is useful for self testing the modem and/or the Model 711. Use SWITCHED CARRIER or CONTINUOUS CARRIER depending upon modem strapping.

TWO-WIRE SWITCHED CARRIER (TWO MODEMS) Figure 8

This configuration is most frequently encountered with modems arranged for operation over switched network (DDD) connection.

NOTE

Following is the standard dial up testing procedure:

(1) Set all controls on local site modem (if any) to NORMAL positions.

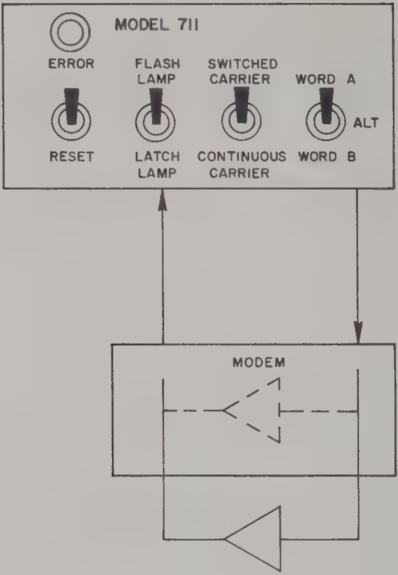
(2) Plug Model 711 test set in place of DTE.

(3) Set WORD A/ALT/WORD B switch on test set to WORD A.

(4) Set FLASH LAMP/LATCH LAMP switch on test set to FLASH LAMP. Set SWITCHED CARRIER/CONTINUOUS CARRIER switch to SWITCHED CARRIER.

(5) Call location of modem to be tested.

When remote modem has finished sending answer tone (if any) and gone into data mode, intermittent "chirps" will be heard in the telephone handset receiver - transmitted from the remote modem.


MODEL 711
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
MODEM

C4405D7A23

Figure 7: Analog Loopback

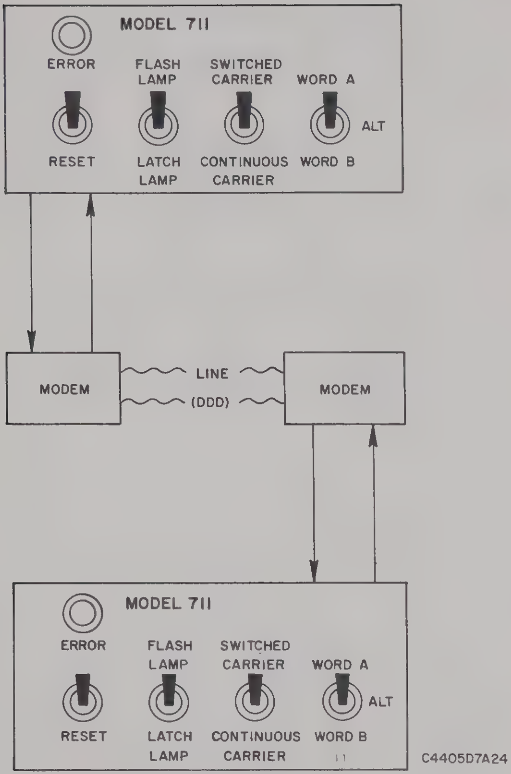

MODEL 711
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
MODEM
LINE
(DDD)
MODEM
MODEL 711
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
C4405D7A24

Figure 8: 2-Wire Switched Carrier

(6) Set local site modem to DATA mode.

Polling sequence will generally start automatically, if not, depress RESET switch on test set and release to start transmit sequence.

NOTE

Local test set will "chirp" as "zero" data bits are received.

(7) Observe ERROR lamp on test set. Any flash indicates that a valid test word was not received before the time-out period ended.

If no "zero" bits are received from remote location, no audible sound will be heard and ERROR lamp will light.

(8) Disconnect may be accomplished by disconnecting manually via the telephone set, by shutting modem power off, or by unplugging test set.

FOUR-WIRE POINT-TO-POINT CIRCUIT Figure 9 and Figure 10

Figure 9 reflects the standard 4-wire continuous carrier operation. In this configuration, the modem at each site is option strapped for continuous carrier operation; therefore, the carrier switch on both Model 711s (local site and remote site) must be placed in the CONTINUOUS CARRIER position.

Figure 10 reflects an alternate application of the Model 711; switched carrier operation over 4-wire. Generally, this configuration is encountered when bench testing two modems. Some difficulty may be encountered when the modems tested have a short CTS delay time (i.e. clear to send delay approximately 8ms versus carrier detect time approximately 7ms). In this case, normal testing of the modems has no inherent inhibiting factors; however, when a self test mode (requiring digital (DTE) loopback at the remote site) is desired, the Model 711 may not work. This is due to the accumulation of two sets of carrier detect times (approximately 14ms), while the CTS delay remains unchanged (approximately 8ms).

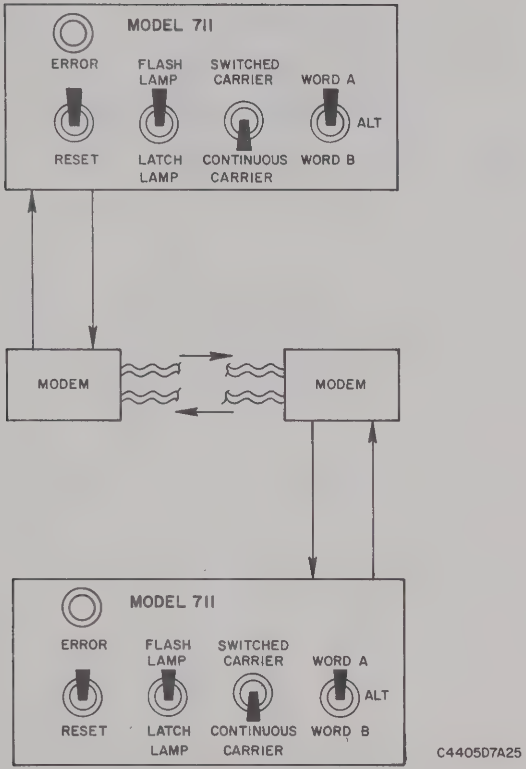

MODEL 711
ERROR
RESET
FLASH LAMP
LATCH LAMP
SWITCHED CARRIER
CONTINUOUS CARRIER
WORD A
ALT
WORD B
MODEM
MODEM
MODEL 711
ERROR
RESET
FLASH LAMP
LATCH LAMP
SWITCHED CARRIER
CONTINUOUS CARRIER
WORD A
ALT
WORD B
C4405D7A25

Figure 9: 4-Wire Continuous Carrier

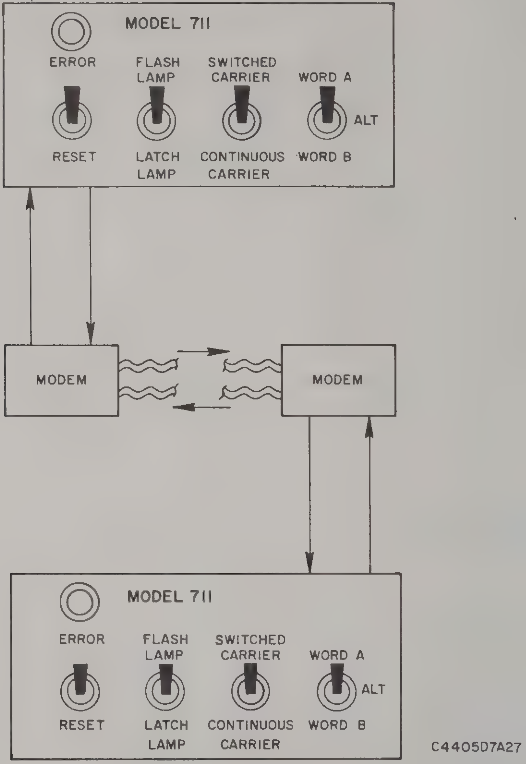

MODEL 711
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
MODEM
MODEM
MODEL 711
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
C4405D7A27

Figure 10: 4-Wire Switched Carrier

NOTE

One solution to this problem is to option strap the remote modem to continuous carrier. Alternate solutions include strapping the local site modem for continuous carrier operation or for a longer CTS delay (> 15ms for the example given above).

FOUR-WIRE POLLED MULTI-DROP SERVICE (3 MODEMS) Figure 11

In this configuration, the modem at the central site transmits a continuous carrier which is received by both remote modems. The remote modems do not transmit until the associated Model 711 detects the correct test word.

4.0 FAULT ISOLATION

The Model 711 Dynamic Test Set does not have self test capabilities; however, for isolation of system faults, the following procedure is recommended.

(1) Connect customer DTE to modem's customer interface (J1) and place modem in Analog Loopback (AL).

(2) Establish (if possible) that EIA circuits in modem are functioning properly.

(3) Replace DTE with Model 711 Test Set by connecting it to modem's DTE Connector. Select test Word A on test set.

(4) If ERROR lamp lights, problem exists in test set or interface cable.

(5) If no ERROR shows, continue with fault isolation first with local then remote modem(s).

e.g with DTE(s) back on line

*1. Local DTE Loopback (DC Loopback)
2. Local Line Loopback (AC Loopback)
*3. Remote Line Loopback (remote AC Loopback)
*4. Remote DTE Loopback (remote DC Loopback)

*if option is available

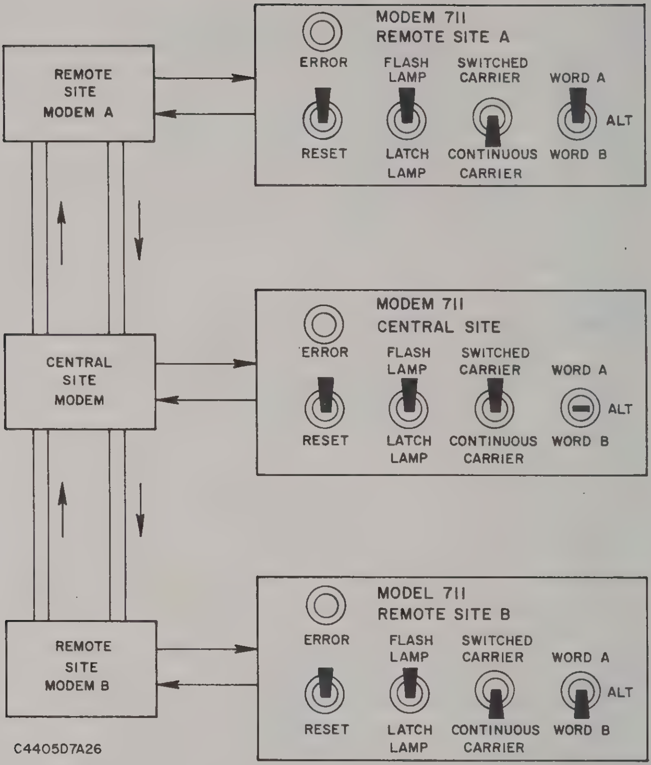

MODEM 711
REMOTE SITE A
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
REMOTE SITE MODEM A
MODEM 711
CENTRAL SITE
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
CENTRAL SITE MODEM
MODEL 711
REMOTE SITE B
ERROR
FLASH LAMP
SWITCHED CARRIER
WORD A
ALT
RESET
LATCH LAMP
CONTINUOUS CARRIER
WORD B
REMOTE SITE MODEM B
C4405D7A26

Figure 11 : 4-Wire Polled Multidrop

4.1 CUSTOMER SUPPORT

If the fault isolation procedure determines that the Model 711 is at fault, the unit must be returned to the factory for repair. The shipping charges must be pre-paid.

The procedure for return is:

(1) Package unit in factory supplied packing material or equivalent carton.

(2) Prepare a letter as follows:

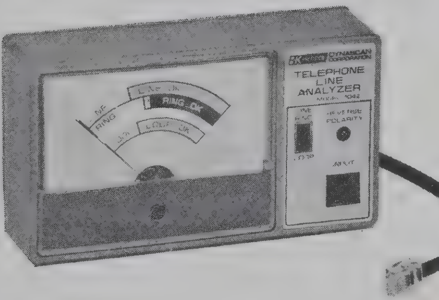
   a) State - Please repair and return.
   b) Give malfunction of unit, if possible.
   c) Give part number and serial number of unit. (Serial number is located on bottom of unit).
   d) Give ship to address to which unit is to be returned.
   e) Give billing address and purchase order under which unit is to be repaired for out of warranty repair charges and shipping charges. If your company does not use a purchase order system, please indicate so.
   f) Enclose copy of letter with unit and ship to g) below. Mail letter to h) below.
   g) Shipping address for unit:
   International Communications Corp.
   7620 N.W. 36th Avenue
   Miami, Florida 33147
   h) Mailing address for letter:
   International Communications Corp.
   8600 N.W. 41st Street
   Miami, Florida 33166
   Attention: Return Clerk

After repair, ICC will return the repaired unit to the customer and will bill the customer for shipping charges (and repair charges for unit(s) out of warranty).

INSTRUCTION
FOLDER

B+K PRECISION 1042

TELEPHONE LINE ANALYZER

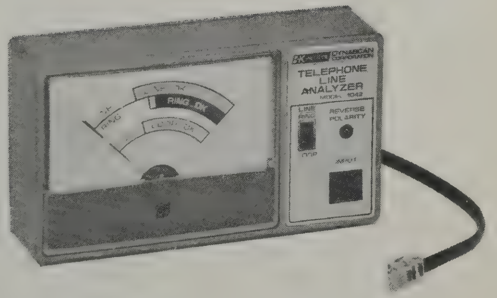

B+K PRECISION DYNASCAN CORPORATION
TELEPHONE
LINE
ANALYZER
MODEL 1042
LINE OK
RING OK
RING
LOOP OK
REVERSE POLARITY
LOOP
INPUT

B+K PRECISION DYNASCAN CORPORATION

INSTRUCTION FOLDER

B+K PRECISION 1042

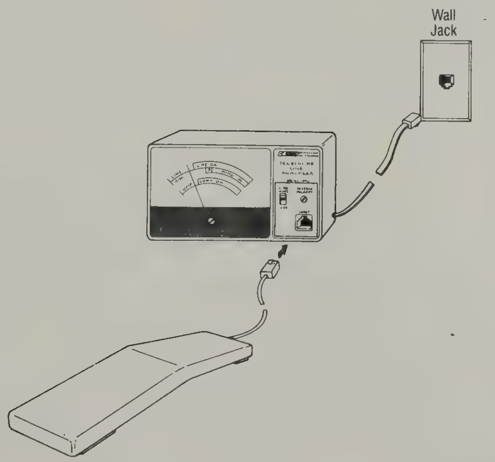
TELEPHONE LINE ANALYZER



B+K PRECISION DYNASCAN CORPORATION

SIMPLIFIED INSTRUCTIONS

For more detailed explanations, see OPERATING INSTRUCTIONS



LINE TEST

1. Connect unit and telephone as shown and hang up all telephone products on the line.
2. Set switch to LINE/RING position.
3. Reading should be in the LINE OK area.
4. Pick up telephone.
5. Reading should drop to near zero deflection and return to LINE OK when telephone is hung up.

RING TEST

1. Connect unit and telephone as shown and hang up all telephone products on the line.
2. Set switch to LINE/RING position.
3. Have someone call your number.
4. Reading should be in RING OK area (needle will vibrate) during ringing.

LOOP TEST

1. Connect unit and telephone as shown and hang up all telephone products on the line.
2. Set switch to LOOP position.
3. Reading should be in the LOOP OK area.
4. Do not leave in LOOP position; calls can not be received and callers will get busy signal.

TELEPHONE CORD TEST

It is only neccesary to perform this test if other tests indicate a good telephone line, telephone is still inoperative, and **the telephone cord is detachable at both ends.**

1. Connect telephone cord between wall jack and jack on Analyzer and plug analyzer's cord into telephone.
2. Set switch to LINE/RING position.
3. While observing the reading, bunch the cord up, squeeze it, and release it.
4. If there is no reading or the reading fluctuates, the cord is defective and must be replaced.

SPECIFICATIONS

DC LINE TEST	
Switch Position:	LINE/RING.
LINE OK:	40 Vdc to 121 Vdc full scale.
Accuracy:	±3% of reading at 40 Vdc.
REVERSE POLARITY:	Indicator on for reverse telephone line polarity (tip voltage negative with respect to the ring conductor).
RING TEST	
Switch Position:	LINE/RING
RING "?":	40 Vrms to 50 Vrms, 20 Hz superimposed on 48 Vdc.
RING OK:	50 Vrms to 130 Vrms, 20 Hz full scale superimposed on 48 Vdc. The REVERSE POLARITY indicator flickers during RING TEST.
LOOP TEST	
Switch Position:	LOOP.
LOOP OK:	Lower end of "LOOP OK" scale corresponds to 20 mA dc developed across 200 Ω internal load. Full scale corresponds to 60 mA.
Accuracy:	±3% of reading at 20 mA dc.
GENERAL:	INPUT jack accepts RJ-11 type plug. Attached telephone cord terminated in 6-position RJ-11 plug.
OPERATING TEMPERATURE:	0° to 50°C.
PHYSICAL SIZE:	HWD (2.75 x 5 x 1.5") (7 x 12.7 x 3.8 cm).
WEIGHT:	7.5 oz (.2 kg).

LIMITED 90-DAY WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of 90 days from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 4050 North Ravenswood Avenue, Chicago, Illinois 60613, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the B & K-Precision products which it sells.

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

To send in the unit for servicing, pack it securely (preferably double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Dynascan Corporation
Factory Service Operations
4050 North Ravenswood Avenue
Chicago, Illinois 60613
Tel (312) 327-7270
Telex: 25-3475

Also use this address for technical inquiries
and replacement parts orders.

B+K PRECISION DYNASCAN CORPORATION
6460 West Cortland
Chicago, Illinois 60635

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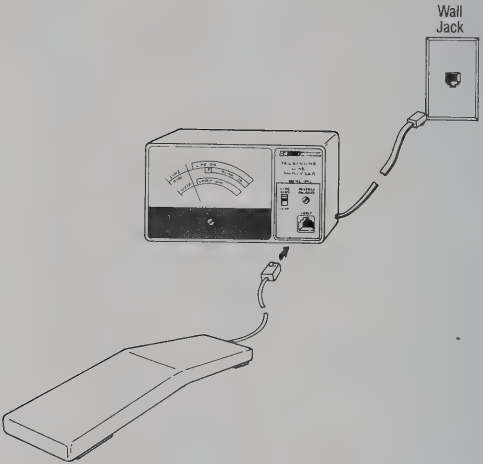
481-161-9-001 Printed in Korea

SIMPLIFIED

For more detailed explanation



LINE TEST

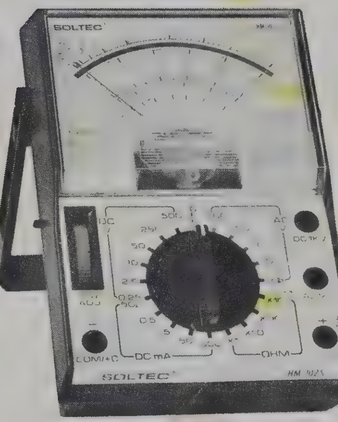
1. Connect unit and telephone as shown and hang up all telephone products on the line.
2. Set switch to LINE/RING position.
3. Reading should be in the LINE OK area.
4. Pick up telephone.
5. Reading should drop to near zero deflection and return to LINE OK when telephone is hung up.

OPERATORS MANUAL

VOM-MULTITESTER

20,000 ohms/volts DC

model HM-102S


SOLTEC
DC
AC
ADJ
COM/+D
DC mA
OHM
SOLTEC
HM 102S

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DISTRIBUTION

LINE TEST

1. Disconnect telephone from wall jack and plug it into INPUT jack on front panel of analyzer.
2. With the analyzer's switch in the LINE/RING position, connect the plug from the analyzer into the modular wall jack. The analyzer can now monitor line conditions with the user's telephone operating. With the telephone hung up (on hook), the analyzer's meter will read the DC voltage that is present on the telephone line.
3. The meter should read in the LINE OK area. If it doesn't, first verify that all telephone devices on the line under test are hung up (on hook). If they are, unplug one device at a time and observe the meter. If unplugging a particular device causes the meter reading to increase, it is likely that the device is defective. A properly operating device causes negligible line loading when hung up. If new wiring has been installed, particularly by the do-it-yourselfer, it should be re-examined and possibly disconnected to verify that it is not loading or shorting the incoming line.
4. If the REVERSE POLARITY Indicator lights, it indicates that the telephone line polarity is reversed. This may be the cause of an operating problem if the telephone is polarity sensitive. All line tests can be made with either polarity (with the REVERSE POLARITY Indicator ON or OFF).
5. Once an acceptable line voltage reading is obtained, pick up each telephone device (go off-hook) and observe the meter. The reading should drop to near zero deflection and return to the normal reading when hung up.

OPERATING INSTRUCTIONS

RING TEST

If ring voltage is not in the RING OK area, check ring voltage at intervals. If total loading on exchange is heavy, ring voltage could be temporarily low. The telephone company's master ring source only has a certain amount of power available.

1. If line voltage appears OK, dial a ring-back number (if available) or have someone call you. When the telephone rings, the meter reading should increase into the RING OK area for the duration of the ring; the pointer will vibrate during ringing. Deflection should be at least 1/8" past the LINE TEST reading. This means that if during the LINE TEST the pointer was already in the RING OK area or very close, the needle should deflect an additional 1/8" or more toward the high end of the scale (measured along the line that separates the RING/LINE scale) during this test.
2. If the telephone does not ring but the meter reading increases into the RING OK area, the telephone's ringer circuit may be defective.
3. If the telephone does not ring and the meter reading is not in the RING OK area, it may be caused by having a large number of telephone products on the line. This may load the ringing signal to the point where it will not ring all the telephone products connected. To determine if this is the problem, add up the ringer equivalence numbers (R.E.N.) indicated on each telephone product. If the total is five or greater, you have exceeded the total ringer equivalence that the telephone company guarantees to ring.
4. Disconnect telephone products one at a time and repeat the RING TEST.

5. If only one telephone is plugged into the line and a low ring reading is observed, unplug the telephone from the analyzer's jack and check whether the ring voltage reading increases significantly. If there is a large increase in the reading, the ringer circuit of the telephone may be defective. If the increase is very small and the meter reading remains in the marginal area, there is a ring voltage problem. Before calling the telephone company, make sure that modifications performed by the user are not the cause of the problem.

NOTE

When the meter reading during this test is in the RING "?" area of the scale, the ringing signal is very close to the minimum voltage guaranteed by the telephone company. Not all telephones will ring in this situation.

LOOP TEST

This test verifies the condition of the telephone line from the central office to the telephone jack in the home.

1. If the "LINE TEST" and "RING TEST" produced low readings after performing all additional checks suggested, the telephone line itself may be the cause of the problem.
2. With all telephone products hung up (on hook), and the analyzer connected as originally instructed (the telephone plugged into the INPUT jack on the analyzer and the analyzer plugged into the wall jack), place the analyzer's switch in the LOOP position. If the meter reading is not in the LOOP OK area, once again, before calling the telephone company, check all telephone products by unplugging one at a time and observing the meter.

3. Before calling the telephone company, repeat the test several times at 15 minute intervals to determine if it is a temporary condition.

NOTE

Do not leave the analyzer connected to the telephone line with the LOOP test selected. This test simulates an off-hook condition. A party attempting to call you will get a busy signal.

TELEPHONE CORD TEST

With the analyzer and the telephone still connected as originally instructed (the telephone plugged into the jack on the analyzer, the analyzer plugged into the wall jack, and the switch on the analyzer in the LINE/RING position), the analyzer may indicate acceptable readings but the telephone may still be inoperative. If so, the telephone cord (between the wall jack and the telephone) may be defective. This test can only be performed on telephone cords that are detachable at both ends.

1. If the telephone line cord is detachable, verify that both ends are properly seated in their sockets.
2. If the telephone is still inoperative, connect the telephone cord between the wall jack and the jack on the analyzer and plug the analyzer's cord into the telephone.
3. Select the LINE/RING test position on the analyzer and, bunch the cord up, squeeze it and release it while checking for abrupt changes in the meter reading.
4. Move the cord up and down and back and forth near each plug and observe the meter.
5. If there is no reading or if the reading fluctuates during steps 3 and 4, the cord is defective and must be replaced.

PARTS LIST AND SCHEMATIC DIAGRAM

PARTS LIST

DESCRIPTION	DYNASCAN PART NO.
RESISTORS	
Unlisted resistors are ±5%, 1/4 W. See schematic diagram for value.	
200 Ω ±5%, 1W	002-001-5-201
100 kΩ Trimmer Pot	008-228-9-001
30 kΩ Trimmer Pot	008-230-9-001
MISCELLANEOUS	
Diode, 1N4004	151-050-9-001
LED, Red	158-057-9-001
Slide Switch, DPDT	084-133-9-001
Panel Meter, 1 mA	320-129-9-001
Modular Jack	777-026-9-001
Modular Cord (RJ-11 with 4' cord)	428-058-9-001
Front Case	271-227-9-001
Back Case	271-228-9-001

CALIBRATION PROCEDURE

1. Set S1 to LINE/RING position. Apply 40 VDC to line input with polarity as shown. Adjust R1 so that needle just touches LINE OK area on M1.
2. Reverse polarity of input voltage. REVERSE POLARITY LED should light and M1 should read within 5% of reading in step 1.
3. Apply a 40 Vrms, 20 Hz signal riding at a 48 VDC level to line input. Reading should be within 5% of lowest area on "RING ?" (on M1).
4. Set switch S1 to LOOP position. Apply 20 mADC to line input. Adjust R2 so that the needle just touches LOOP OK area of M1.

PARTS ORDERING INFORMATION

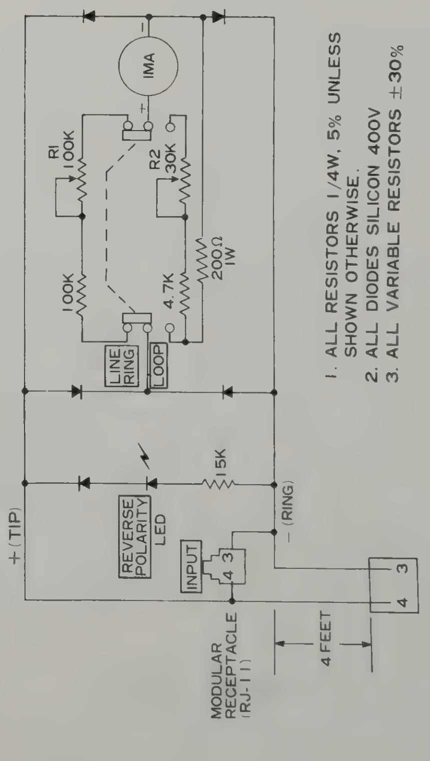
There is a minimum charge for each invoice. Orders will be shipped C.O.D. unless previous open account arrangements have been made or remittance accompanies order. Advance remittance must cover handling and postage or express charges. Specify model and serial number when ordering replacement parts.

ORDER REPLACEMENT PARTS FROM:

B & K-Precision, Dynascan Corporation
Factory Service Operations
4050 North Ravenswood Avenue
Chicago, Illinois 60613
Telephone (312) 327-7270
Telex: 25-3475

Also use this address for technical inquiries.

MODEL 1042 TELEPHONE LINE TESTER SCHEMATIC



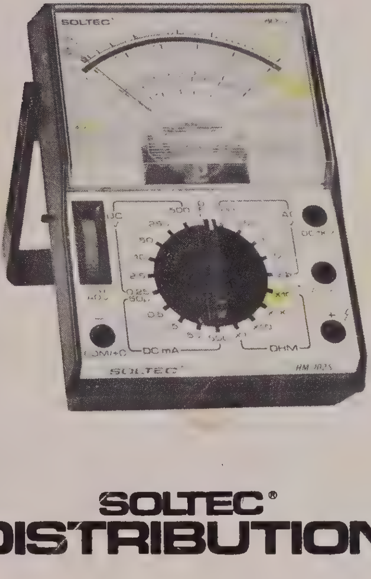
1. ALL RESISTORS 1/4W, 5% UNLESS SHOWN OTHERWISE.
2. ALL DIODES SILICON 400V
3. ALL VARIABLE RESISTORS ±30%

OPERATORS MANUAL

VOM-MULTITESTER

20,000 ohms/volts DC

model HM-102S


SOLTEC
DC V
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250
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10
2.5
0.25
50µ
0.5
5
50
500
OFF
AC
x10
x1
x1K
x10K
COM/+C
DC mA
OHM
SOLTEC
HM-102S

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DISTRIBUTION

SECTION 1
INTRODUCTION

1. 1 GENERAL

1. 1. 1 The SOLTEC HM-102S Volt-Ohm-Milliammeter (hereafter referred to as the HM-102S or the Instrument) is a high sensitivity instrument (20,000 ohms/volt DC and 8,000 ohms/volt AC), ideal for use where measurements must not appreciably disturb the circuit being tested.

1. 1. 2. Built in a modern high-impact case, the HM-102S is a quality product in both performance and appearance. Available are seven DC and six AC voltage ranges, five dB ranges, five DC current ranges and four resistance ranges. A mirrored dial is included to help eliminate errors in readings due to parallax and a dB conversion chart is printed on the dial face. Special circuitry has been included to protect the meter movement against accidental overloads. Another feature of the Instrument is a built-in, convenient carrying handle which can also be used to position the HM-102S at an angle for easy reading. An optional carrying case is also available.

1. 2. SPECIFICATIONS

1. 2. 1. DC Voltage

Ranges: 0-0.25, 2.5, 10, 50, 250, 500, 1000V
(separate jack)
Sensitivity: 20,000 ohms/volt
Accuracy: ±3% of full scale

1. 2. 2. AC Voltage

Ranges: 0-2.5, 10, 50, 250, 500, 1000V
(separate jack)
Sensitivity: 8,000 ohms/volt
Accuracy: ± 5% of full scale

1. 2. 3. DC Current

Ranges: 0-50μA, 0.5, 5, 50, 500mA
Accuracy : ±3% of full scale

1. 2. 4. Decibels

Ranges : −20dB to 56dB in 5 ranges (0dB: 1mW @ 600Ω)

1. 2. 5. Resistance

Ranges : 0-20 megohms in 4 ranges (center scale at 20, 200, 20K, 200KΩ).
Accuracy : ±3° of arc

1. 2. 6. Power Requirements: Two 1.5 volt "AA"
type batteries,
NEDA type 15F, and
one 9 volt battery,
NEDA type 1604.

1. 2. 7. Fuse: Littlefuse 2112.002 (2A) Fast Acting
(or equivalent)

1. 2. 8. Dimensions: 3½" wide x 5¼" long x 1½" high

1. 2. 9. Weight: 10.8 ounces (including batteries).

1. 3. ITEMS FURNISHED WITH INSTRUMENT

One set of test leads, one 9 volt and two 1.5 volt batteries, one fuse and an operator's manual.

SECTION II
CONTROLS AND JACKS

2. 1. GENERAL

2. 1. 1. All operating and adjustment controls, and jacks are described in this section. The operator should become familiar with each item prior to operating the Instrument.

1. **Function and Range Switch:** This control is located in the lower center of the front panel and it combines the operations of selecting the function and desired range as well having an "OFF" position. To extend the life of the batteries, the switch should be in this ' OFF" position when the Instrument is not in use.

2. **Zero Ohms Adjust Control:** Located on the left side of the front panel this control is used to obtain a "0" indication on the ohms scale when the test leads are shorted together. During operation, the zero indication should be checked each time the ohmmeter is to be used. This permits compensation for the aging of the internal batteries. If the zero adjustment cannot be made, replace batteries.

3. **Zero Mechanical Adjust:** This adjustment is the plastic screw located in the bottom center of the dial cover and is used to correct any pointer error (off "0"). when the Instrument is in an operating position.

4. **(–)COM/+Ω Jack** : Plug in connection for black (negative) test lead.

5. **(+)V–Ω–A Jack:** Plug in connection for red (positive) test lead for all ranges except when measuring AC and DC voltages exceeding 500.

6. **DC 1KV Jack :** Plug in connection for red test lead when making measurements between 500 and 1000 volts DC. Function and Range switch must be set in the "500 & UP" position.

7. **AC 1KV Jack :** Plug in connection for red test lead when making measurements between 500 and 1000 volts AC. Function and Range switch must be set in the "500 & UP" position.

SECTION III
OPERATION

3. 1. SAFETY PRECAUTIONS

3. 1. 1. Instruments of this type are intended to be used only in low-power product type applications such as radio, TV, personal computers and the like.

3. 1. 2. Frequently inspect the test leads and the Instrument for damage and/or deteriorating insulation and replace faulty items immediately.

3. 1. 3. Never work alone with high voltage circuits.

3. 1. 4. Before connecting the Instrument to a circuit, become familiar with the circuit to determine the highest voltage levels likely to be encountered.

3. 1. 5. The small size of this Instrument might tempt the user to hold it while making measurements. Avoid this practice especially when working in circuits that might contain a shock hazard.

3. 1. 6. Develop safe habits by turning off the power to the measured circuit and discharge any capacitors before handling the test leads.

3. 1. 7. If the approximate value of the voltage or current to be measured is not known, always set the Instrument to its highest range for the first measurement to determine the proper range to be used.

3. 1. 8. Electrical measurements to be made in the presence of humidity or moisture are particularly hazardous. Hands, shoes, floor and workbench must be dry.

3. 1. 9. When making resistance measurements, all power to circuits must be removed and capacitors discharged.

3. 2. PARALLAX ERRORS

3. 2. 1. To avoid such errors, take the reading when the reflection of the pointer in the mirror is directly behind the pointer (one image only).

3. 3. MEASURING DC VOLTAGES

a. Select the required DC voltage range.
b. Connect the black lead to the (–) jack and the red lead to the (+) jack for all voltage ranges except the 1KV range. For the 1KV range connect red lead to the DC 1KV jack.
c. Turn on power in the circuit to be measured.
d. Observing polarity, connect the test leads across the circuit or component where the voltage is to be measured.
e. Read the DC voltage on the appropriate scale.

3. 4. MEASURING AC VOLTAGES

a. Select the required AC voltage range.
b. Connect the test leads as noted in paragraph 3.3 b (above), except for the 1KV range. For the 1KV range connect the red lead to the AC 1KV jack.
c. Turn on power to the circuit to be measured.
d. Connect the test leads across the circuit or component where the voltage is to be measured.
e. Read the AC voltage on the appropriate scale.

3. 5. MEASURING DC CURRENT

a. Select the required DC current range.
b. Connect the test leads to the(+) and(–) jacks.
c. Turn on power in the circuit to be measured.
d. Observing polarity, connect the test leads in series with the circuit or component to be measured
d. Observing polarity, connect the test leads in series with the circuit or component to be measured with the most positive potential to the(+) jack.
e. Read the DC current on the appropriate scale.

3. 6. MEASURING RESISTANCE

a. Select the required OHM range.
b. Connect the test leads to the(+) and (−)jacks
c. Short the contact ends of the test leads and observe the indication on the Instrument.
d. Set the 0Ω AJD knob for a meter pointer indication of 0 ohms (full scale). If unable to adjust for 0, replace both 1.5 volt batteries or if the R x 10K range scale is affected replace the 9V battery (refer to paragraph 4. 2).
e. Connect test leads across the resistance which is to be measured. Observe polarity if there is a "forward" or "backward" resistance (as in the case of diodes). The polarity of output when in OHM ranges is opposite to jack markings, i.e., the + jack is negative with respect to the − jack.
f. Read the indication on the Ω (ohms) scale at the top of the dial. Note that the arc reads from right to left for increasing values.
g. Multiply the reading by the multiplier factor selected in the switch range position.

3. 7. MEASURING DECIBELS

a. Select the 500 & UP ACV range (if voltage is unknown).
b. Connect the test leads as noted in paragraph 3.5 b (above).
c. Turn on the power in the circuit to be measured.
d. Connect the test leads across the circuit or component where the voltage is to be measured.
3. Read the dB scale. Adjust ranges "downward", if appropriate, until the largest scale indication is attained.

NOTE: The dB scale is calibrated to a reference level of one milliwatt into 600Ω where 0dB is 0.774V and read directly on the 2.5 VAC range. For readings of greater than 10dB, greater voltage ranges are required and the dB values that are to be "added" to the direct scale reading are exhibited in a conversion table on the lower right hand corner of the dial face.

Example: Using the 10 ACV range the total dB's measured would be the direct scale reading plus 12. On the 50 ACV range, plus 26, etc..

SECTION IV
MAINTENANCE

4. 1. REMOVAL OF CASE BACK

4. 1. 1. The Instrument has been designed to provide easy access for all necessary replacement of parts. It is only necessary to remove one screw from the back of the Instrument (center of the case) to remove the back of the case to gain access to the batteries and the fuse.

4. 2. BATTERY REPLACEMENT

4. 2. 1. Remove the back of the case.

4. 2. 2. Note the orientation and location of all the batteries. When the Ohms Adjust control cannot be adjusted for zero ohms (with shorted test leads) it is generally an indication that one or both of the 1.5 volt "AA" batteries needs replacement for any or all the ranges except the R x 10K. (It is recommended that both batteries be replaced at the same time.) The R x 10K range battery is the 9 volt battery.

4. 2. 3. Remove the old batteries and replace with new, noting the + indication in the 1.5 volt battery compartments. The 9 volt battery has a self-polarizing snap-on connector. Make sure that the battery terminals in each compartment make good contact with the battery, otherwise resistance measurements would be erroneous.

4. 2. 4. Replace back of case, insert the plastic screw and tighten snugly, being careful not to overtighten.

4. 3. FUSE REPLACEMENT

4. 3. 1. Should the Instrument stop working it is possible that the fuse has blown.

CAUTION

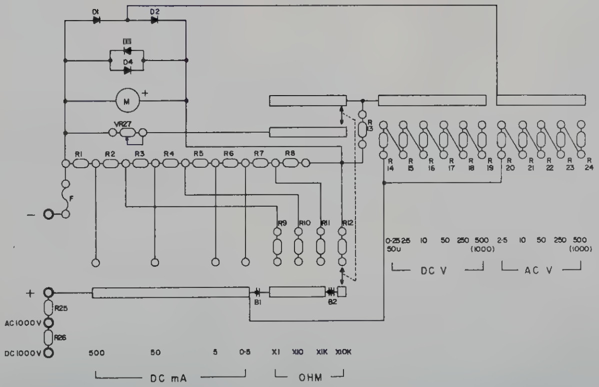
To ensure maximum protection to the Instrument, do not replace the fuse with one of different type voltage rating, or with a "slo-blo" type.

4. 3. 2. Remove the back of the case.

4. 3. 3. Inspect and replace fuse if necessary.

4. 3. 4. Replace back of case.

SCHEMATIC DIAGRAM


D1
D2
D3
D4
M
+
VR27
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
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AC1000V
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DC1000V
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DC V
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50
250
500
(1000)
AC V
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50
5
0·5
DC mA
X1
X10
X1K
X10K
OHM

R1	0 8
R2	2 5
R3	4 7
R4	25 3
R5	46 7
R6	720
R7	2 53K
R8	4 67K
R9	15 2
R10	166 8
R11	18 1K
R12	198 4K
R13	1 2K
R14	2 2K
R15	45K
R16	150K
R17	800K
R18	4 M
R19	5 M
R20	19 16K
R21	66 2K
R22	355K
R23	1 77M
R24	2 21 M
R25	4 42M
R26	5 7M
VR27	30K
M	2K40 uA
D1,3,4	S1 IN914
D2	GeIN 60
B1	1 5V x2 "AA"
B2	9VX1 "006P"
F	2A250V

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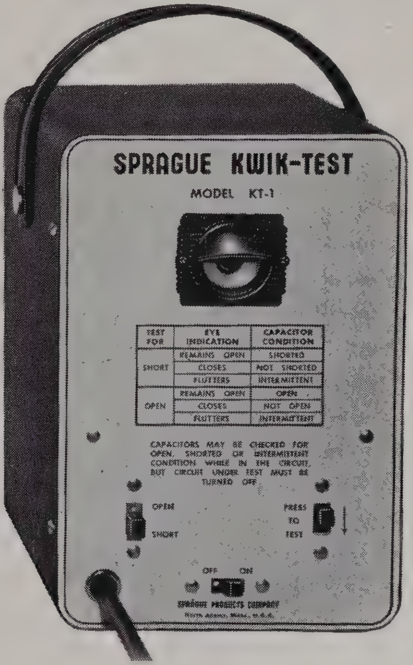
T-108a

SPRAGUE®

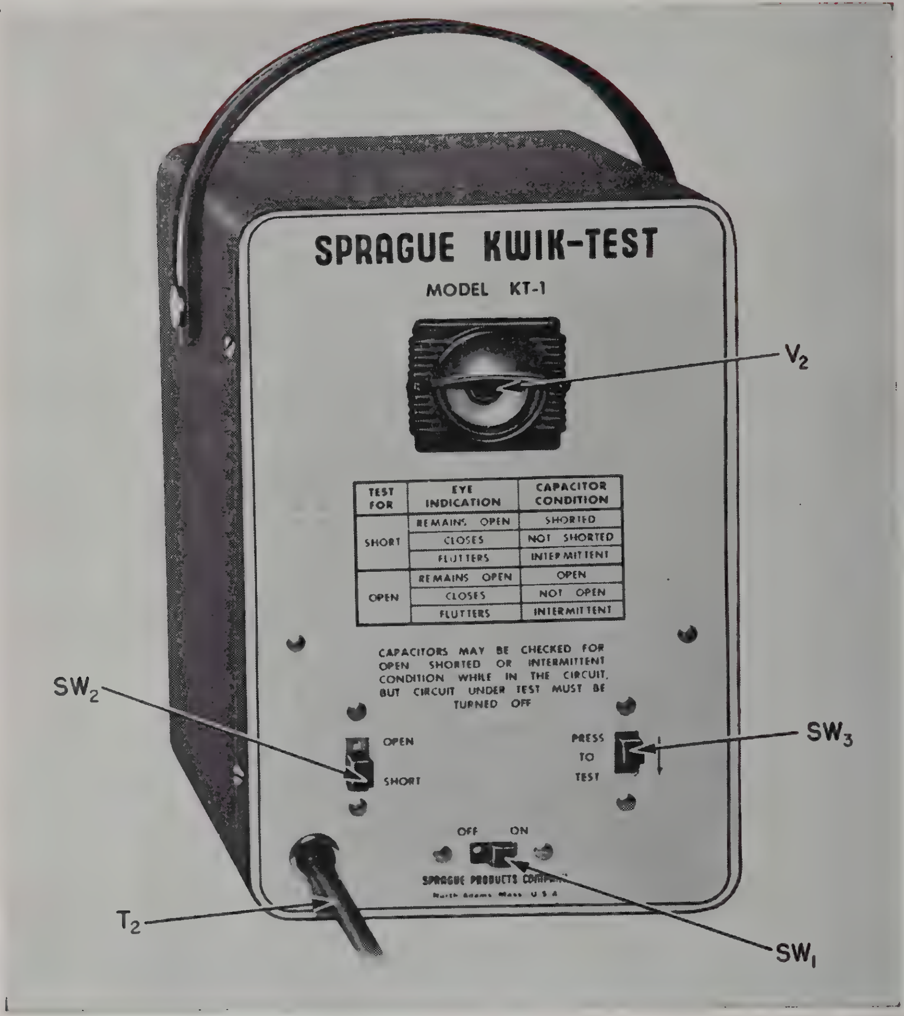
OPERATING MANUAL


SPRAGUE KWIK-TEST
MODEL KT-1
TEST FOR
EYE INDICATION
CAPACITOR CONDITION
SHORT
REMAINS OPEN
SHORTED
CLOSES
NOT SHORTED
FLUTTERS
INTERMITTENT
OPEN
REMAINS OPEN
OPEN
CLOSES
NOT OPEN
FLUTTERS
INTERMITTENT
CAPACITORS MAY BE CHECKED FOR OPEN, SHORTED OR INTERMITTENT CONDITION WHILE IN THE CIRCUIT, BUT CIRCUIT UNDER TEST MUST BE TURNED OFF
OPEN
SHORT
PRESS TO TEST
OFF
ON
SPRAGUE PRODUCTS COMPANY
North Adams, Mass., U.S.A.

MODEL KT-1
KWIK-TEST
CAPACITOR CHECKER

SPRAGUE PRODUCTS COMPANY

The KT-1 Kwik-Test is a supplementary instrument to the TO-4 Capacitor-Resistor Analyzer. It checks capacitors in the circuit only for opens, short, and intermittents. Other tests, such as measuring leakage current or insulation resistance, must be made with the TO-4.


SPRAGUE KWIK-TEST
MODEL KT-1
V2
SW2
OPEN
SHORT
PRESS TO TEST
SW3
OFF
ON
SPRAGUE PRODUCTS COMPA
North Adams Mass. U.S.A
T2
SW1

TEST FOR	EYE INDICATION	CAPACITOR CONDITION
SHORT	REMAINS OPEN	SHORTED
	CLOSES	NOT SHORTED
	FLUTTERS	INTERMITTENT
OPEN	REMAINS OPEN	OPEN
	CLOSES	NOT OPEN
	FLUTTERS	INTERMITTENT

CAPACITORS MAY BE CHECKED FOR OPEN SHORTED OR INTERMITTENT CONDITION WHILE IN THE CIRCUIT, BUT CIRCUIT UNDER TEST MUST BE TURNED OFF

The Sprague Kwik-Test is carefully calibrated to check capacitors under circuit conditions. If it should be necessary to check tubular type multiple section electrolytic capacitors out of the circuit, erroneous results may be obtained when checking opens. This can be corrected by using a 50 mmf ceramic or mica capacitor in series with the "+" lead or terminal of the capacitor under test. The "short" test can be performed in the regular manner.

Operating Manual

MODEL KT-1 KWIK-TEST

1. General Description

1.1 Purpose and Usefulness: The Sprague Model KT-1 KWIK-TEST is designed specifically to meet the need of TV and Radio Service Engineers for an instrument that will quickly and easily indicate OPEN, SHORTED, or INTERMITTENT capacitors without removing them from their circuit. Any capacitor within the range of 30 μμf to 2,000 μf may be easily checked for these defects even though in parallel with a resistance as low as 60 ohms. Capacitors between .1 and 2,000 μf may be tested for SHORTS and intermittent shorts even though in parallel with a resistance as low as 2 ohms. Capacitors smaller than 30 μμf will indicate OPEN even though they are good, while those larger than 2,000 μf will indicate SHORT even though they are in good condition. Neither the OPEN or SHORT test will give correct results if the capacitor is in a parallel resonant circuit tuned to a frequency higher than 10 mc. While the capacitor may be tested without removing it from its circuit, the circuit under test MUST be turned OFF. If it becomes necessary to determine the actual capacitance, along with insulation resistance (of paper, mica or ceramic capacitors), or power factor and leakage current of electrolytic capacitors, then a bridge such as the SPRAGUE TEL-OHMIKE MODEL TO-4 is needed.

1.2 LINE VOLTAGE and FREQUENCY: The KT-1 is designed for use only on a 115 V. 50-60 cycle AC line. Model KT-1X is available for use on 115/230 V. 25-60 cycles.

1.3 DC OPERATION: Under NO circumstances should a KT-1 or KT-1X be plugged into a DC Outlet. *ALWAYS* use an inverter power supply (either vibrator or rotary type) that will supply the needed 25 watts of a-c power.

1.4 PHYSICAL APPEARANCE: The medium gray wrinkle finish steel case, with plastic handle, and the light gray panel with clear black markings make the KT-1 an instrument that attracts favorable attention, and commands respect on any service bench. The overall size of the KT-1 is 9″ high x 6″ wide by 5-1/4″ deep.

1.5 The net weight of the KT-1 is 6 lbs.

1.6 TUBE COMPLEMENT: Two (2) type 1626 and one (1) 1629 are used in the KT-1.

1.7 COMPONENTS: The components used in the KT-1 were engineered for long, dependable service. Molded Sprague Telecap® paper capacitors are used wherever practical. The fixed capacitors in the μμf range are Sprague Cera-Mites, while the trimmers are of the silver-ceramic type. The power transformer and RF oscillator coil are treated to resist the effects of moisture. The wire wound resistor used in the SHORT test is a famous Sprague Koolohm®. Metal parts are suitably treated to resist corrosion.

2. Short Test

2.1 Fig. 1 shows the basic circuit of the SHORT test which operates as follows: If the test clips are shorted, the voltage at the grid of the "eye" tube is zero (maximum opening). If the clips are open, the entire voltage appears at the grid of the "eye" tube, which causes it to close. Thus a shorted capacitor will cause the "eye" to remain open, while a normal capacitor will cause it to close either partially or completely depending upon its reactance, and the circuit in parallel with it.

2.2 OPERATING PROCEDURE:

1. Set the line switch, in the lower center of the panel, in the ON position.
2. Place the Test Selector switch in the lower left portion of the panel in the SHORT position.
3. Connect the test clips to the terminals of the capacitor to be tested.
4. Press the PRESS-TO-TEST switch, in the lower right portion of the panel, down and watch the action of the "eye" tube.
5. If the "eye" remains completely open (no change of shadow angle as the switch is pressed) the capacitor is shorted and should be replaced.
6. If the "eye" closes (even slightly in the case of large capacitors in parallel with small values of resistance), the capacitor is not shorted, and should be given the OPEN test.
7. Tap the capacitor sharply. If the "eye" flutters, the capacitor is intermittent, and should be replaced.

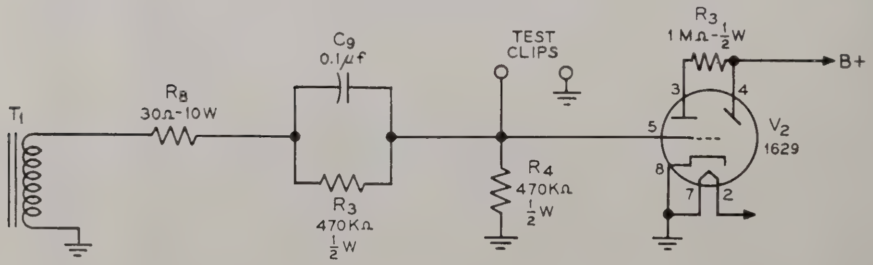


Figure 1 — "Short Test" Circuit

3. Open Test

3.1 Fig. 2 shows the basic circuit of the OPEN test which operates as follows: Test cable T_2 and impedance Z_1 constitute a quarter wave transmission line operating at a frequency of approximately 20 mc. A useful property of a quarter wave line is utilized in this test namely that the impedance connected to the output end of the line is reflected to the sending end as a reciprocal, i.e., if the output is shorted the input end "sees" an open circuit. In operation if the test clips are open (or are connected to an open capacitor), the sending end (coupling coil L_2) "sees" a short circuit (zero voltage), which causes the "eye" to remain open. Any capacitance connected to the clips results in a voltage across L_2 (which is rectified by the 1N51), and then impressed upon the grid of the "eye". This d-c voltage causes the "eye" to close in proportion to its magnitude. A small capacitor causes a small closure, while a large capacitor causes the "eye" to close completely.

3.2 OPERATING PROCEDURE:

1. Connect test clips to the terminals of the capacitor under test.
2. Place the Test Selector switch in the OPEN position.
3. Press the PRESS-TO-TEST switch, and watch "eye" tube.
4. If the "eye" remains completely open (no change of shadow angle as the switch is pressed), the capacitor is open.
5. If the "eye" closes (even slightly in the case of small capacitors – the capacitor must be larger than 200 μμf to completely close the "eye") the capacitor is not open. Note: If when testing electrolytic or other metal cased capacitors a small closure is noted, this indication is due to internal lead and terminal capacitance and should be disregarded. Thus large capacitors which show only a small closure are open and should be replaced.
6. Tap the capacitor sharply. If the "eye" flutters, the capacitor is intermittent.

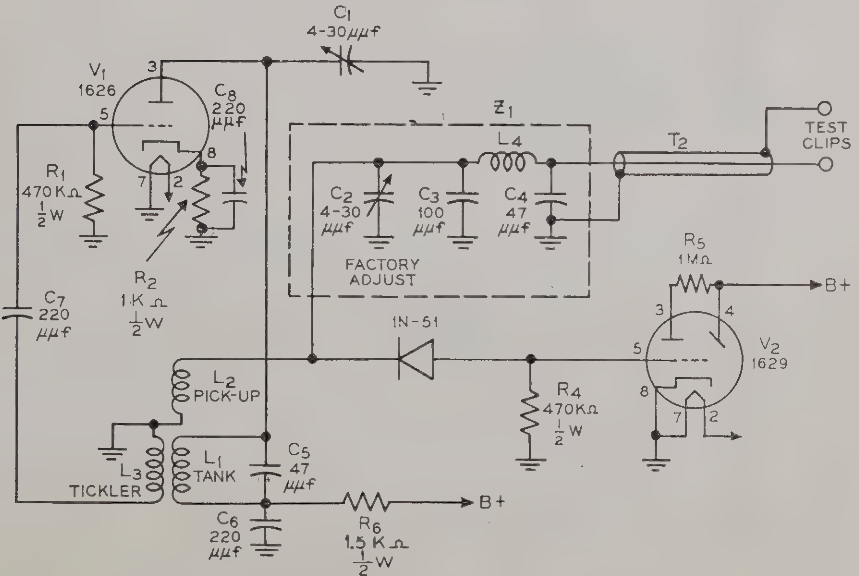

C1
4-30μμf
V1
1626
3
5
C8
220
μμf
8
R1
470KΩ
1/2 W
7
2
Z1
L4
T2
TEST
CLIPS
C2
4-30
μμf
C3
100
μμf
C4
47
μμf
FACTORY
ADJUST
R5
1MΩ
B+
R2
1K Ω
1/2 W
C7
220
μμf
1N-51
3
4
5
V2
1629
L2
PICK-UP
R4
470KΩ
1/2 W
8
7
2
L3
TICKLER
L1
TANK
C5
47
μμf
C6
220
μμf
R6
1.5 KΩ
1/2 W
B+

Figure 2 — "Open Test" Circuit

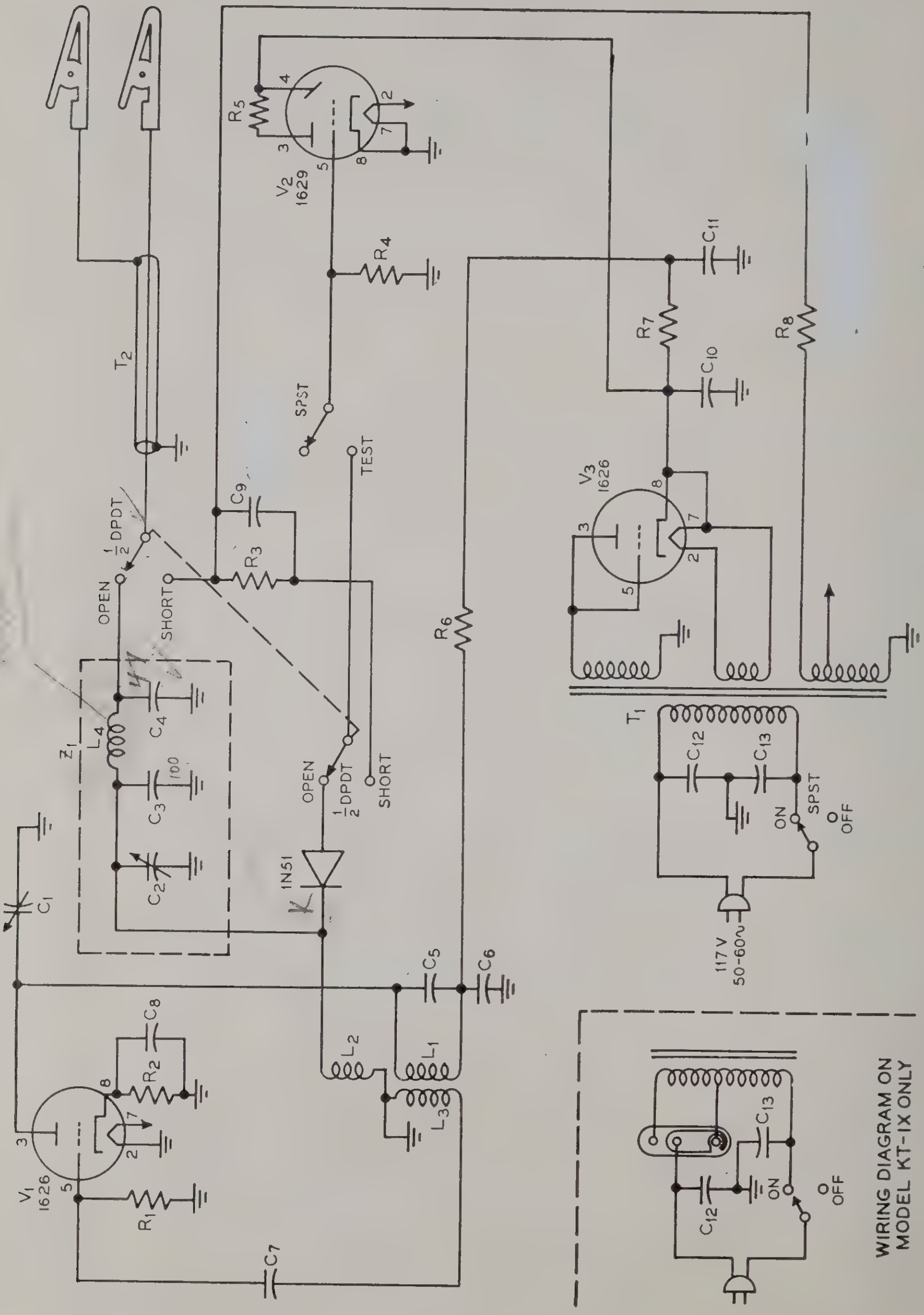

T2
½ DPDT
OPEN
SHORT
Z1
L4
C4
C3
100
C2
C1
1N51
OPEN
½ DPDT
SHORT
TEST
SPST
C9
R3
R4
R5
V2
1629
R6
C5
C6
C8
R2
V1
1626
R1
C7
L1
L2
L3
C10
C11
R7
R8
V3
1626
T1
C12
C13
SPST
ON
OFF
117 V
50-60~
C13
C12
ON
OFF
WIRING DIAGRAM ON
MODEL KT-1X ONLY

Figure 5 — Complete Circuit Diagram

4. Readjustment

4.1 Although the oscillator and the artificial line of the OPEN TEST of the KT-1 have been designed for long-time stability, under certain conditions of temperature and humidity readjustment may be necessary. This may be determined easily and, if needed, can be quickly made.

4.2 To test the operation of the OPEN TEST, set the Test Selector to the OPEN position and Press the PRESS-TO-TEST switch down, with the test clips not connected to any capacitor, and watch the action of the "eye". There should be no change of shadow angle as the PRESS-TO-TEST switch is operated. If there is any change, remove the plug button from the rear of the case and very slowly adjust the trimmer capacitor, C_1, which is now accessible, at the same time operating the PRESS-TO-TEST switch and watching the "eye". The trimmer is correctly adjusted when the operation of the switch produces no change of shadow angle of the "eye". This is the only adjustment of the instrument that is required. Do not try to adjust unless the unit is thoroughly warmed up for at least 30 minutes.

5. Miscellaneous Hints

5.1 **DO NOT ALTER** the length of the test lead under any conditions since it is a part of the quarter-wave line as explained in 3.1. Should the insulated test clip break off, it should be resoldered without making any large change in the length of the cable. If this is done, the instrument should be checked as directed in 4.2.

5.2 Return your KT-1 Registration Card within five (5) days of the date of purchase in order to obtain the benefits of the Sprague warranty.

5.3 Always give model and serial number of your instrument when corresponding regarding it. The serial number is located on the rear of the chassis below the line cord.

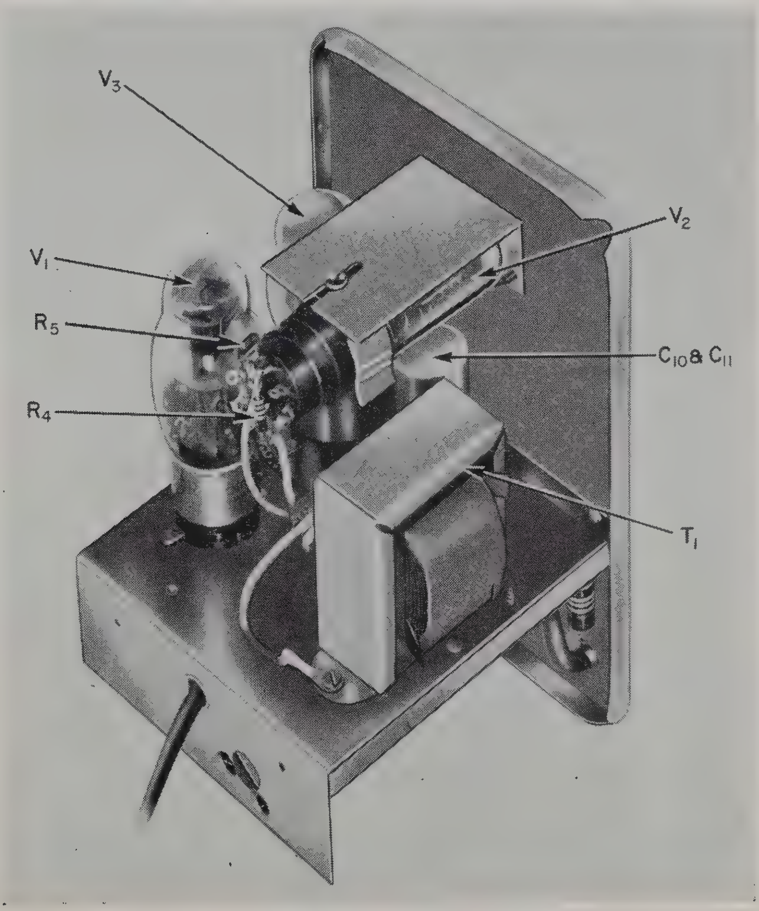
5.4 If it should ever be necessary to return your KT-1 for service, write giving complete details of the difficulty you are having, and detailed instructions and labels will be furnished for shipping the instrument to your nearest authorized service depot. This procedure will save you time and money.

LIST OF MAINTENANCE PARTS

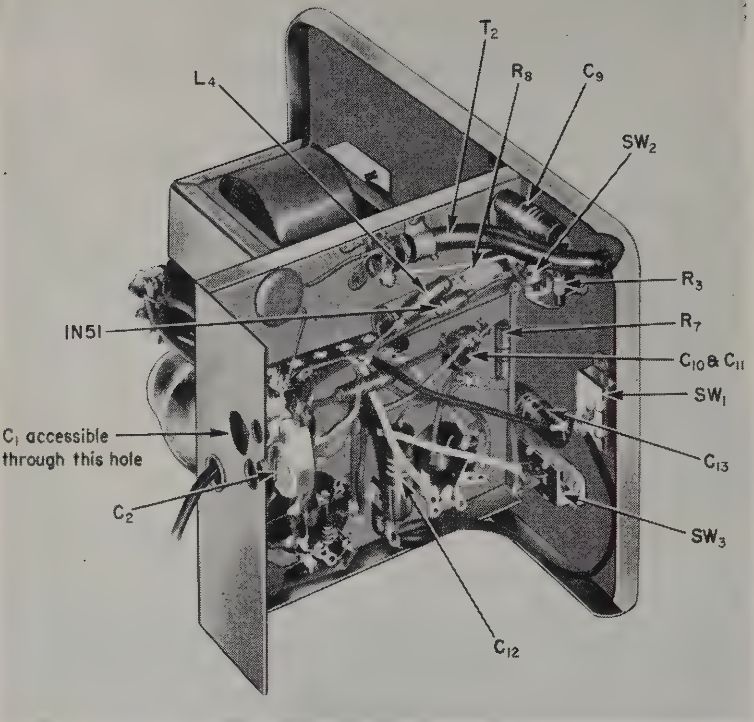
Circuit Symbol	Replacement Part No.	Description
L_1 L_2 L_3	3-312	Coil, oscillator, 20 mc.
L_4	3-313	Coil, loading, artificial quarter wave line.
R_1 R_3 R_4	2-113-10	Resistor, fixed, composition, 470K ohms, ±10%, ½ watt.
R_2	2-49-10	Resistor, fixed composition, 1000 ohms, ±10%, ½ watt.
R_5	2-121-20	Resistor, fixed, composition, 1 Meg. ±20%, ½ watt.
R_6 R_7	2-302-20	Resistor, fixed, composition, 1500 ohms, ±20%, 1 watt.
R_8	2-761	Resistor, fixed, wire wound, 30 ohms, ±5%, 10 watt, Sprague Koolohm, Type 10KT.
T_1	3-94	Transformer, filament, power & short test for KT-1.
T_1	3-94-X	Transformer, filament, power & short test for KT-1X.
C_1 C_2	1-1001	Capacitor, adjustable dual trimmer, silver ceramic 4-30 μμf.
C_3	1-842	Capacitor, fixed, ceramic dielectric 100 μμf. ±10%, 500 V., SL.
C_4	1-841	Capacitor, fixed, ceramic dielectric 47 μμf. ±10%, 500 V., SL.
C_5	1-840	Capacitor, fixed, ceramic dielectric 47 μμf. ±10%, 500 V., N750.
C_6 C_7 C_8	1-843	Capacitor, fixed, ceramic dielectric 220 μμf. ±20%, 500 V., SL.
C_9	1-105	Capacitor, fixed, molded paper - dielectric .1 μf. ±20%, 200 V., Sprague 67P10402.
C_{10} C_{11}	1-518	Capacitor, fixed, dry electrolytic 10 + 10 μf. 300 WVDC, Sprague Type TVL.

LIST OF MAINTENANCE PARTS — Cont.

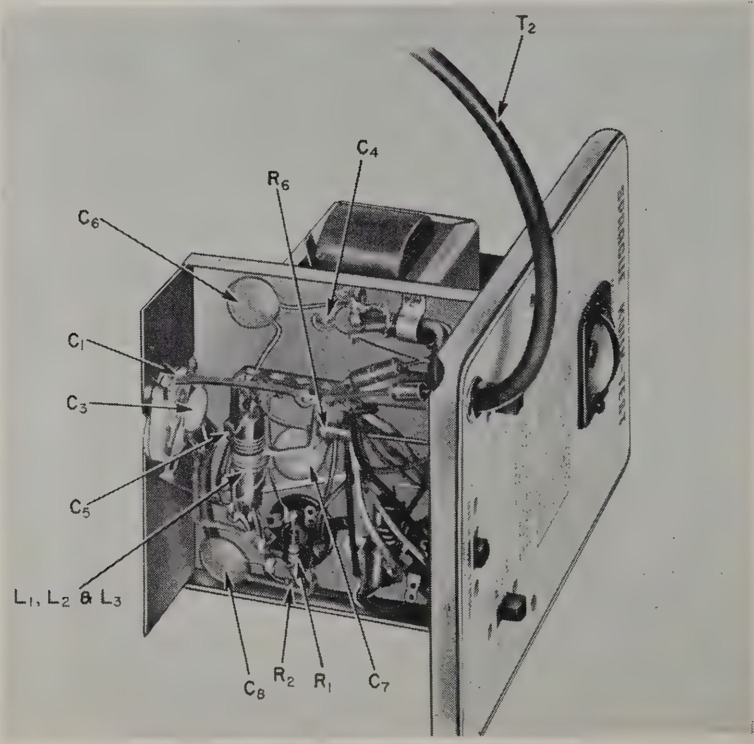
Circuit Symbol	Replacement Part No.	Description
C_{12} C_{13}	1-830	Capacitor, fixed, molded paper-dielectric .018 μf. ±10%, 400 V. Sprague 67P18394.
T_2	6-25	Cable, test probe, RG-54/U, 48″ long, complete with clips and ground lead
V_1 V_3	5-1626	Tube, electron, type 1626
V_2	5-1629	Tube, electron, type 1629
	5-1N51	Rectifier, crystal type 1N51
SW_1	11-76	Switch, slide, SPST
SW_2	11-82	Switch, slide, DPDT
SW_3	11-76	Switch, slide, SPST



View from Right Rear


T2
R8
C9
L4
SW2
R3
IN51
R7
C10 & C11
SW1
C1 accessible
through this hole
C13
C2
SW3
C12

View Under Chassis Looking Forward


T2
C4
R6
C6
C1
C3
C5
L1, L2 & L3
C8
R2
R1
C7

View Under Chassis Looking Toward Rear

STANDARD MODEL KT-1
WARRANTY

The Sprague Products Company warrants each Kwik-Test to be free from defective material and workmanship and agrees to remedy any such defect or to furnish a new part in exchange for any part of any unit of its manufacture which under normal installation, use and service discloses such defect, provided the unit is delivered by the owner to us intact, for our examination, with all transportation charges prepaid to our factory or authorized service station within ninety days from the date of sale to original purchaser and provided that such examination discloses in our judgment that it is thus defective.

This Warranty does not extend to any Kwik-Test which has been subjected to misuse, neglect, accident, incorrect wiring not our own, improper installation, or to use in violation of instructions furnished by us, nor extend to units which have been repaired or altered outside of our factory nor to cases where the serial number thereof has been removed, defaced or changed.

Any part of a unit approved for remedy or exchange hereunder will be remedied or exchanged by us without charge to the owner.

This Warranty is in lieu of all other Warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

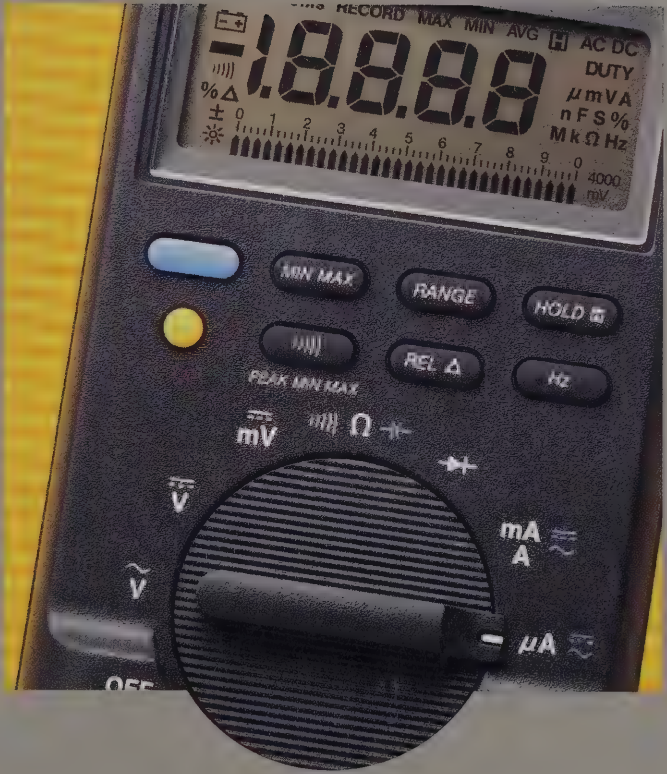
If the return of this instrument is deemed necessary, advise SPRAGUE PRODUCTS COMPANY, NORTH ADAMS, MASS., giving full details. Our reply and complete shipping instructions will reach you within five (5) days after receipt of your letter. NO ADJUSTMENTS WILL BE MADE UNLESS OUR CONSENT FOR THE RETURN OF THE INSTRUMENT IS OBTAINED BEFORE MAKING SHIPMENT.

NOTE: RETURNED INSTRUMENTS MUST BE PACKED CAREFULLY, MARKED FRAGILE, AND SHIPPED BY PREPAID EXPRESS.

SPRAGUE PRODUCTS COMPANY
North Adams, Mass.

SPRAGUE

Don't Be Vague!
Insist on
SPRAGUE CAPACITORS
For Dependability

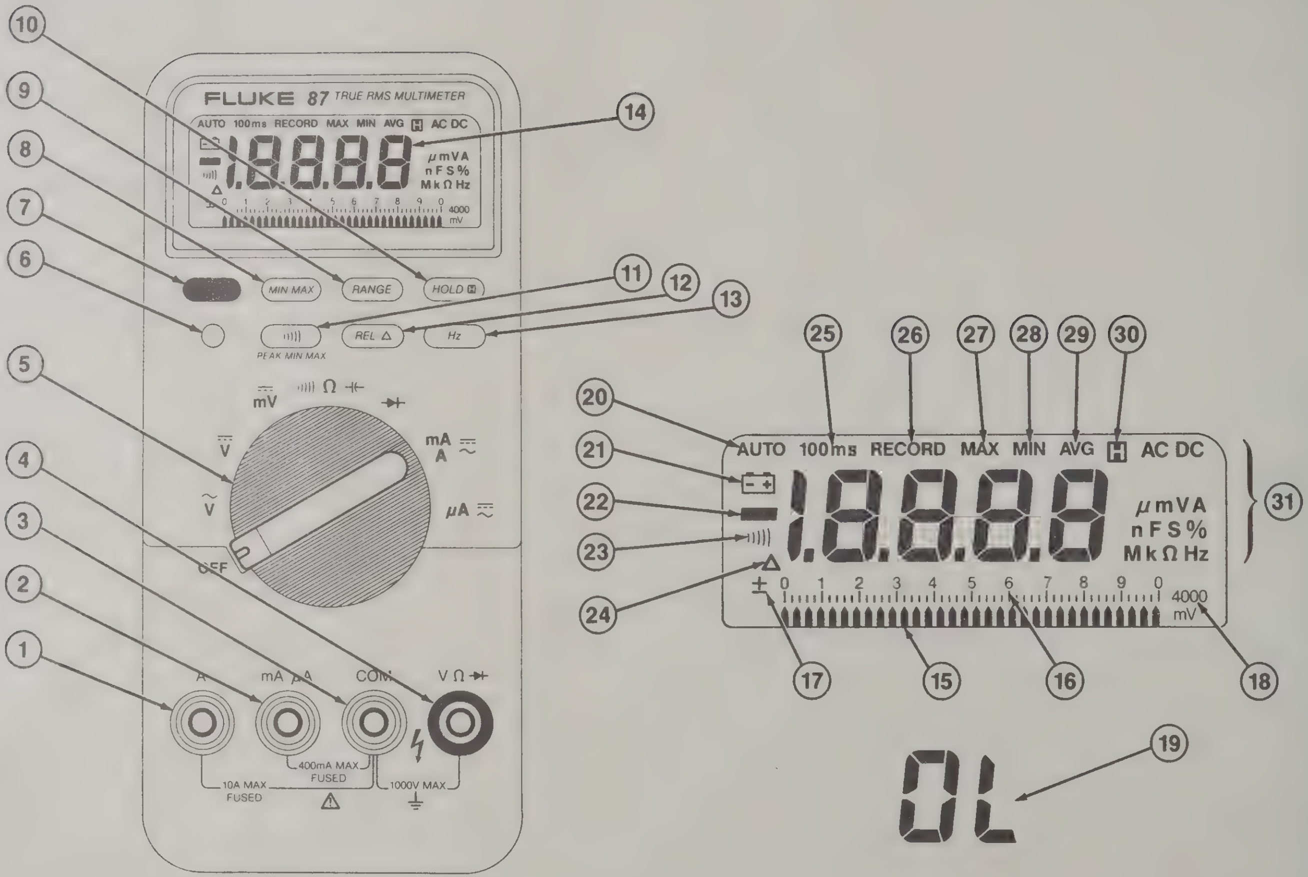

RECORD MAX MIN AVG AC DC
DUTY
µ m V A
n F S %
M k Ω Hz
0 1 2 3 4 5 6 7 8 9 0
4000 mV
MIN MAX
RANGE
HOLD
REL Δ
Hz
PEAK MIN MAX
mV
Ω
mA
A
µA
V
OFF

87 TRUE RMS MULTIMETER

USER'S MANUAL

FLUKE

FLUKE AND PHILIPS - THE GLOBAL ALLIANCE IN TEST & MEASUREMENT


FLUKE 87 TRUE RMS MULTIMETER
AUTO 100ms RECORD MAX MIN AVG H AC DC
-1.8.8.8.8
µ m V A
n F S %
M k Ω Hz
0 1 2 3 4 5 6 7 8 9 0
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PEAK MIN MAX
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V
mA
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1000V MAX
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87 TRUE RMS MULTIMETER

USER'S MANUAL

P/N 834192
August 1988
Rev. 1, 2/89
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FLUKE

FLUKE AND PHILIPS - THE GLOBAL ALLIANCE IN TEST & MEASUREMENT

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INTRODUCTION

NOTE

This meter has been designed and tested according to IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus. This manual contains information and warnings which must be followed to ensure safe operation and retain the meter in safe condition.

WARNING

READ "MULTIMETER SAFETY" BEFORE USING THE METER.

The Fluke 87 True RMS Multimeter (also referred to as "the meter") is a handheld, 4000-count instrument that is designed for use in the field, laboratory, and at home. The meter combines the precision of a digital meter with the speed and versatility of a high resolution analog display. Frequencies between 0.5 Hz and 200 kHz can be measured with up to 0.01 Hz resolution. The meter is powered by a 9V battery and has a rugged case sealed against dirt, dust, and moisture. A snap-on holster, with flexible stand (Flex-Stand™), protects the meter from rough handling. The flexible stand allows the meter to be stood or hung.

The meter also provides:

- A MIN MAX Recording mode, in which the meter "remembers" the lowest and highest readings, calculates the true average of all readings taken over a period 3 6 → as long as tw~~enty-four~~ hours, and displays these values. The beeper emits a Min Max Alert™ when a new minimum or maximum reading is recorded.
- A Peak MIN MAX mode that captures changes as short as 1 millisecond.
- An alternate Frequency Counter mode that measures duty cycle and displays it as a value between 0.0 and 99.9%.
- An Input Alert™ that causes the beeper to sound if the test leads are plugged into the wrong input terminals for the function being performed.
- A REL mode that allows you to store a reading in memory, and display the difference between the stored value and subsequent readings.
- A Touch Hold® mode that allows you to keep your eyes fixed on the probes when taking measurements in difficult or hazardous circumstances, then read the display when it is convenient and safe.

™Input Alert, Flex-Stand, and MIN MAX Alert are trademarks of the John Fluke Mfg. Co., Inc.
®Touch Hold is a registered trademark of the John Fluke Mfg. Co., Inc.

- A display back-light that makes the meter useable in dark areas.
- A 4½-digit display mode for ten times increase in resolution.
- A Capacitance mode that measures capacitors from 0.01 nF to 5 μF.

After unpacking the meter, if you notice that the meter is damaged or something is missing, contact the place of purchase immediately. Save the shipping container and packing material in case you have to reship the meter.

MULTIMETER SAFETY

Before using the meter, read the following safety information carefully. In this manual the word, "**WARNING**," is reserved for conditions and actions that pose hazard(s) to the user; the word, "**CAUTION**," is reserved for conditions and actions that may damage your meter. The symbols shown in Figure 1 are used internationally to denote the electrical functions and conditions indicated.

- Avoid working alone.
- Inspect the test leads for damaged insulation or exposed metal. Check test lead continuity. Damaged leads should be replaced.
- Be sure the meter is in good operating condition. During a continuity test, a meter reading that goes from overload (OL) to 0 generally means the meter is working properly.
- Select the proper function and range for your measurement.

WARNING

TO AVOID ELECTRICAL SHOCK, USE CAUTION WHEN WORKING ABOVE 60V DC OR 25V AC RMS. SUCH VOLTAGES POSE A SHOCK HAZARD.

ϟ	DANGEROUS VOLTAGE	⏚	GROUND
~	AC – ALTERNATING CURRENT	⚠	SEE EXPLANATION IN MANUAL
⎓	DC — DIRECT CURRENT	⧈	DOUBLE INSULATION (Protection Class II)
⎓ ~	EITHER DC OR AC	⏛	FUSE

Figure 1. International Electrical Symbols

- Disconnect the live test lead before disconnecting the common test lead.
- Follow all safety procedures for equipment being tested. Disconnect the input power and discharge all high-voltage capacitors through a protective impedance before testing in the Ω and →| functions.
- When making a current measurement, turn the power off before connecting the meter in the circuit.
- Check meter fuses before measuring current transformer secondary or motor winding current. (See "Fuse Test" in the "MAINTENANCE" Section.) An open fuse may allow high voltage build-up, which is potentially hazardous.

GETTING STARTED QUICKLY

Examine the meter carefully, familiarizing yourself with the layout of the input terminals, rotary switch, pushbuttons and display. Notice the WARNING information and summary of power-on options engraved into the rear panel.

If you have used a multimeter before, simply examining your meter will probably give you a good idea how to use it. The following procedure is an overview of how to take basic measurements.

WARNING

TO AVOID ELECTRICAL SHOCK OR DAMAGE TO THE METER, DO NOT APPLY MORE THAN 1000V BETWEEN ANY TERMINAL AND EARTH GROUND.

1. Insert the test leads in the appropriate input terminals (see Table 1). If the test leads are in the wrong input terminals when the meter is turned on and the beeper has not been disabled, the beeper will emit a warning. See "Input Terminals and Input Alert", below.

2. To turn the meter on and select a function, turn the rotary switch from OFF to the appropriate switch position. All segments on the liquid-crystal display (LCD) will turn on for one second, then the meter is ready for normal operation. If you would like to freeze the display with all segments on, press and hold down any button, while turning the meter on. As long as the button is held down, all LCD segments will remain on.

3. To select an additional operation, press the appropriate pushbuttons above the rotary switch as described in the items below. (See also, Figure 2.)

- To operate the MIN MAX and RANGE buttons: press to select, press again to scroll or increment, and press and hold for two seconds to exit.

- To operate the Hz button: press to select the frequency mode, press again to select duty cycle, and press again to exit.

- To operate the back-lit display, press the YELLOW button. The back-light automatically turns off in 68 seconds to conserve battery life.

- To operate the remaining buttons: press to select and press again to exit.

NOTE

The response of the display and the pushbuttons slows down in the capacitance mode.

An annunciator is displayed when a mode has been selected. A quick way to reset all the pushbuttons to their default state is to turn the rotary switch to an adjacent function and then back to the function you are using.

4. To take a measurement, use the test lead probes to make the proper contacts. Remember, insert the meter in the circuit in parallel for voltage and in series for current measurements. Read the measurement on the display. If you did not manually select a range (by using the RANGE button), the range that provides the best resolution is automatically selected.

5. To run a performance check of the meter, turn the rotary switch to Ω and connect a test lead from the VΩ→+ input to the mA μA input. (If you are using a test probe, touch the half of the input contact nearest the LCD.) The display should read 1.000 kΩ ± 5 digits. With the rotary switch still at Ω, test the A fuse (15A) by inserting the plug end of the test lead into the A input and test the mA μA fuse (1A) by inserting the plug end of the test lead into the mA μA input. The beeper emits an Input Alert if the fuses are good.

Although this procedure will allow you to get started quickly, we suggest that you take the time to read the remainder of this manual so that you can learn to take full advantage of your meter's capabilities.

HOW TO USE THE METER

This section describes your meter and how to use it. *FOR EASE OF REFERENCE, EACH DESCRIPTION IS NUMBERED AND KEYED TO THE ILLUSTRATION INSIDE THE FRONT COVER.*

Table 1. Input Terminals and Limits

FUNCTION	INPUT TERMINALS Red Lead	Black Lead	MIN DISPLAY READING	MAX DISPLAY READING	MAXIMUM INPUT
~ V	VΩ ▶|	COM	0.1 mV	1000V	1000V
⎓ V	VΩ ▶|	COM	0.0001V	1000V	1000V
⎓ mV	VΩ ▶|	COM	0.01 mV	400.0 mV	1000V
Ω	VΩ ▶|	COM	0.01Ω	40.00 MΩ	1000V †
nS	VΩ ▶|	COM	0.001 nS	40.00 nS	1000V †
⊣⊢	VΩ ▶|	COM	0.01 nF	5.00 μF	1000V †
▶|	VΩ ▶|	COM	0.0001V	3.000V	1000V †
mA A ⎓ ~	A	COM	1 mA	20.00A*	10A/600V*
	mA/μA	COM	0.01 mA	400.0 mA	400 mA/600V
μA ⎓ ~	mA/μA	COM	0.1 μA	4000 μA	400 mA/600V

**10A continuous, 20A for 30 seconds maximum.*

† For circuits < 0.3A short circuit, 660V for high energy circuits.

Input Terminals and Input Alert

Items 1-4 describe the input terminals. (See Table 1 for overload limits.) If the test leads are incorrectly connected, the beeper will emit an Input Alert. After an Input Alert sounds, the meter attempts to take a reading and respond to button pushes. Input Alert can be disabled by pressing (ııı)) while turning the rotary switch from OFF to any function position.

① **A** **Amperes Input Terminal**

For current measurements (ac or dc) up to 10A continuous (20A for 30 seconds) when function selector switch set to $\overset{\text{mA}}{\text{A}}$ ≂.

② **mA μA** **Milliamp/Microamp Input Terminal**

For current measurements up to 400 mA (ac or dc) when the function selector switch is set to $\overset{\text{mA}}{\text{A}}$ ≂ or μA ≂.

③ **COM** **Common Terminal**

Return terminal for all measurements.

④ **VΩ ▶|** **Volt, Ohms, Diode Test Input Terminal**

Function Selector Rotary Switch

⑤ Item 5 describes functions that are selected by setting the rotary switch. Each time the rotary switch is moved from OFF to a function setting, all LCD segments will turn on for one second as part of a selftest routine. (This selftest routine is also performed if the rotary switch is turned slowly from one position to another.) The meter is then ready for normal operations and will respond to the rotary switch and pushbuttons.

OFF

Power to the meter is turned off.

$\overset{\sim}{\text{V}}$ **Volts ac**

Autoranges to the 400 mV, 4V, 40V, 400V or 1000V range.

$\overset{=}{\text{V}}$ **Volts dc**

Autoranges to the 4V, 40V, 400V or 1000V range.

$\overset{=}{\text{mV}}$ **Millivolts dc**

Single 400 mV range.

ERRATA #2

On page 6, replace the paragraph following "Input Terminals and Input Alert" with the following:

> Items 1-4 describe the input terminals. (See Table 1 for overload limits.) If the test leads are connected to the Amperes input terminal, and the function selector switch is not in the Amp measurement position, the beeper will emit an Input Alert. An Input Alert will also sound if the test leads are connected to the mA uA terminal and the function switch is not in either Amp position. After an Input Alert sounds, the meter will attempt to take a reading from inputs applied to the VΩ·▶|· terminal. Input Alert can be disabled by pressing •))) while turning the rotary switch from OFF to any function position.

Title: 87 User's
Print Date: August 1988
Rev.- Date: 1, 2/89

C/E PAGE EFFECTIVITY

Page No.	Print Date
1	12/89
2	12/89
3	12/89
4	3/90

•))) Ω ⊣⊢ Resistance (Ω), conductance (1/Ω), capacitance or continuity •))) testing

Press BLUE button to toggle between the resistance and capacitance function. (The response of the display and the pushbuttons slows down in the capacitance mode.)

Autoranges to the 400Ω, 4 kΩ, 40 kΩ, 400 kΩ, 4 MΩ, or 40 MΩ resistance range.

In Manual Ranging mode, 40 nS conductance range (equal to a 25-100,000 MΩ range) is selectable. (See item 9.)

Autoranges to the 05.00 nF, .0500 µF, 0.500 µF, and 05.00 µF capacitance range.

When testing continuity, the beeper sounds if the resistance falls below the typical values indicated in Table 2.

⊳| Diode Test

Measures forward voltage of semiconductor junction(s) at approximately 1 mA test current. Single 0-3V range.

mA A ≂ Milliamps or amperes

Defaults to dc. Press BLUE button to toggle between dc and ac.

Autoranges to the 40 mA or 400 mA range when using the mA µA input terminal, or to the 4000 mA or 10A range when using the A input terminal.

µA ≂ Microamps.

Defaults to dc. Press BLUE button to toggle between dc and ac.

Autoranges to the 400 µA or 4000 µA range when using the mA µA input terminal.

Table 2. Beeper Responses in Continuity Test

Input Range	Beeper On If
400.0Ω	< 40Ω
4.000 kΩ	< 200Ω
40.00 kΩ	< 2 kΩ
400.0 kΩ	< 20 kΩ
4.000 MΩ	< 200 kΩ
40.00 MΩ	< 200 kΩ

Pushbuttons

Items 6-13 describe how to use the pushbuttons. These buttons are used (in conjunction with rotary switch) to select operating modes and set power-on options. When a button is pushed the beeper sounds (unless the beeper has been turned off or the Data Output mode has been selected). A summary of pushbutton operations is shown in Figure 2. An annunciator is displayed to indicate that a mode or option has been selected. A quick way to reset all the pushbuttons to their default state is to turn the rotary switch to an adjacent function and then back to the function you are using.

⑥ ○ Display Back-Light

Press the YELLOW button to turn on the back-light. Back-light turns off automatically after 68 seconds to extend battery life.

Power-On Option: 4½-Digit Display Mode

The meter displays the readings at 10 times the resolution with a maximum display at 19,999 counts. The display is updated once per second. The 4-½ digit display mode works in all functions except capacitance, Peak MIN MAX and 100 millisecond MIN MAX.

⑦ ● AC or DC, Resistance or Capacitance

Press BLUE button to toggle between ac and dc when measuring current, or between capacitance and resistance when the rotary switch is set to ·))) Ω ⊣⊢.

Power-On Option: Disable Automatic Power-off

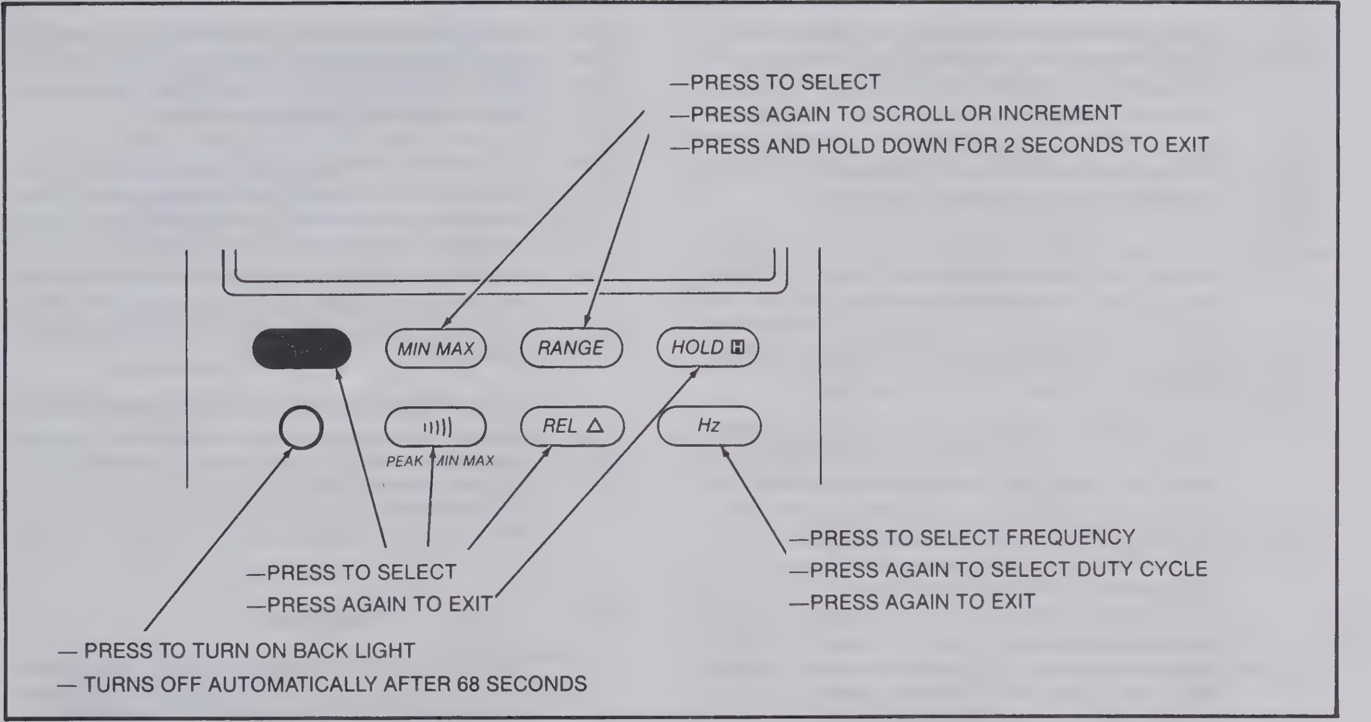
Automatic Power-off extends the life of the battery by turning the meter off if neither the rotary switch nor a pushbutton is operated for half an hour. (Automatic Power-off is not allowed in the MIN MAX Recording or Data Output modes.) The meter turns back on if either the rotary switch is turned or a pushbutton is pressed.

(MIN MAX) Minimum (MIN), Maximum (MAX), Average (AVG) Recording

⑧ Press (MIN MAX) to enter the MIN MAX Recording mode (manual range only). Select the proper range before selecting MIN MAX to ensure that the min max reading will not exceed the measurement range. The minimum, maximum, and average values are then reset to the present input; the RECORD annunciator turns on; the AUTO annunciator turns off; and the automatic power-off feature is disabled.

In the MIN MAX Recording mode, the minimum and maximum readings are stored in memory. ¶ The beeper emits a tone when a new minimum or maximum value is recorded. Push (MIN MAX) to cycle through the maximum (MAX), minimum (MIN), average (AVG), and present readings. The MIN, MAX, or AVG annunciator turns on to indicate what value is being displayed. If an overload is recorded, the averaging function is stopped and the average value becomes OL (overload).

a continuous beeper tone is emitted when an overload is recorded



—PRESS TO SELECT
—PRESS AGAIN TO SCROLL OR INCREMENT
—PRESS AND HOLD DOWN FOR 2 SECONDS TO EXIT

—PRESS TO SELECT
—PRESS AGAIN TO EXIT

—PRESS TO SELECT FREQUENCY
—PRESS AGAIN TO SELECT DUTY CYCLE
—PRESS AGAIN TO EXIT

— PRESS TO TURN ON BACK LIGHT
— TURNS OFF AUTOMATICALLY AFTER 68 SECONDS

Figure 2. Summary of Pushbutton Operations

The true average of all the readings taken over at 36 → least a ~~thirty-fi~~ve hour period can be displayed. If this duration is exceeded, the actual minimum and maximum readings will continue to be captured and can be displayed. However, new averages are no longer calculated. The last average calculated is retained as the average reading.

At normal (default) record speed, changes to the voltage, current, or resistance inputs that last at least 100 milliseconds are recorded, and the "100 ms" annunciator turns on. Press and hold down the (MIN MAX) for 2 seconds to exit and erase recorded readings.

In the MIN MAX mode, press (ıı))) to select the Peak MIN MAX mode ("1 ms", "RECORD", and "MAX" are displayed). Voltage or current inputs that last for 1 milliseconds or longer are captured. Press (MIN MAX) to select the minimum (MIN) reading. Press again to return to the maximum (MAX) reading. To reset the Peak MIN MAX mode press (ıı))) twice: the first press exits the mode, and the second press re-enters the mode. To completely exit the MIN MAX mode, press (MIN MAX) for one second. In Peak MIN MAX mode, the present reading, average (AVG) readings, and analog display are not displayed. Before selecting Peak MIN MAX, select DC voltage or current to DC couple the input waveform; or AC voltage to capacitively couple the input waveform. Peak MIN MAX works in all functions except ohms, frequency and capacitance.

In the MIN MAX Recording mode, press (HOLD ⊡) to stop the recording of readings; press again to restart recording. If recording is stopped, the minimum, maximum, average, and present values are frozen, but the analog display continues to be active. When recording is stopped, the stored readings are not erased and you can still scroll through these readings.

Power-On Option: Select High Accuracy MIN MAX Recording

The High Accuracy MIN MAX Recording mode has a response time of approximately 1 second. Changes of more than 1 second duration are recorded. The "1 s" annunciator is turned on. In the Frequency Counter mode, readings are always recorded at the high accuracy recording speed; the response time is not selectable.

⑨ (RANGE) Manual Ranging

Press (RANGE) to select the Manual Range mode and turn off the AUTO annunciator. (The meter remains in the range it was in when manual ranging was selected.)

In the Manual Range mode, each time you press (RANGE) button, the range (and the input range annunciator) increments, and a new value is displayed. If you are already in the highest range, the meter "wraps around" to the lowest range. (In the Frequency Counter mode, pressing (RANGE) manually selects the input voltage or current range.) To exit the Manual Range mode and return to autoranging, Press and hold down (RANGE) for 2 seconds. The AUTO annunciator turns back on.

When the range is changed manually, the Touch Hold, MIN MAX Recording, and REL[ative] modes are disabled.

Power-On Option: Rotary Switch Test

The Rotary Switch Test is used only for servicing purposes. See the 80 Series Service Manual for details. In the Rotary Switch Test mode, normal meter functions are disabled. To exit the Rotary Switch mode, turn the rotary switch to OFF and back to any switch setting.

⑩ (HOLD H) Display Hold

WARNING

TOUCH HOLD WILL NOT CAPTURE UNSTABLE OR NOISY READINGS. DO NOT USE TOUCH HOLD TO DETERMINE THAT CIRCUITS WITH DANGEROUS VOLTAGE ARE DEAD.

Press (HOLD H) to toggle in and out of the Touch Hold mode, except if you are already in the MIN MAX Recording or Frequency Counter mode.

In the Touch Hold mode, the H annunciator is displayed and the last reading is held on the display. When a new, stable reading is detected, the beeper emits a tone, and the display is automatically updated. Pressing (MIN MAX) when you are in the Touch Hold mode causes you to exit Touch Hold and enter the MIN MAX Recording mode.

In the MIN MAX Recording mode, press (HOLD H) to stop the recording of readings; press (HOLD H) again to resume recording. (Previously recorded readings are not erased.)

In the Frequency Counter mode (Hz), press (HOLD H) to stop the display; press (HOLD H) again to start it.

Power-On Option: Ultrasonic Data Output

This mode is used during the manufacturing and service of your meter. In Data Output mode, the beeper, operating at about 16 kHz, transmits all displayed information at around 800 bps. All other beeper functions are disabled, and the reading rate is slowed by half.

⑪ ıı))) Continuity Beeper/Peak MIN MAX

Press ıı))) to toggle the beeper on or off for continuity testing in the ohms function.

The beeper responds as indicated in Table 2.

In the Frequency Counter mode, press ıı))) to change the trigger slope from positive-going edges to negative-going edges. The slope selected is indicated by the analog display polarity annunciator (±).

In the MIN MAX mode, press ıı))) to toggle in and out of the Peak MIN MAX mode. See item 8.

Power-On Option: Disable Beeper

When the beeper has been disabled, all beeper functions are turned off. The beeper is automatically disabled if the meter is in the Data Output mode.

⑫ REL △ Relative Readings

Press REL △ to enter the Relative mode, zero the display, and store the displayed reading as a reference value. The relative mode annunciator (△) is displayed. Press REL △ again to exit the relative mode. ✓

In the Relative mode, the value shown on the LCD is always the difference between the stored reference value and the present reading. For example, if the reference value is 15.00V and the present reading is 14.10V, the display will indicate -0.90V. If the new reading is the same as the reference value, the display will be zero.

⑬ Hz Frequency Counter Mode and Duty Cycle

Press the Hz to select the Frequency Counter mode; press again to select duty cycle (the alternate counter function); press again to exit. The analog display does not operate in either the Frequency Counter mode or duty cycle.

In Frequency Counter mode, the Hz annunciator is displayed. The frequency function autoranges over five ranges: 199.99 Hz, 1999.9 Hz, 19.999 kHz, 199.99 kHz, and greater than 200 kHz. The RANGE button manually selects the voltage or current input range. If duty cycle is selected, readings from 0.0 through 99.9 are displayed. The "Hz" annunciator turns off and "%" turns on.

Power-On Option: High Input Impedance Mode

The input impedance of the ⎓mV function (400 mV range) is changed from 10 megohms to greater than 4000 megohms.

Summary of Power-on Options

You can select a number of options each time you turn the meter on. These power-on options (also listed on the rear of the meter) are selected by holding down one or more of the pushbuttons while turning the function switch to any ON position. All power-on options are only disabled when the rotary switch is turned to OFF. Each power-on option is discussed in detail under "Pushbuttons" and summarized in Table 3.

Digital and Analog Display

Items 14-19 describe the digital and analog displays and LCD annunciators.

⑭ Digital Display

Digital readings are displayed on a 4000-count display with polarity (±) indication and automatic decimal point placement. When the meter is turned on, all display segments and annunciators appear briefly during a selftest. The display updates four times per second, except when frequency readings are taken. Then the update rate is 3 per second.

Table 3. Options Available at Power-on

OPTION	PUSHBUTTON	FUNCTION
Automatic Power-off	BLUE	Disable Automatic Power-off
4½ Digit Mode	YELLOW	Select 4½ digit display. Full scale 19,000 counts.
MIN MAX Record Speed	MIN MAX	Select High Accuracy record speed. (Response time approximately 1 second)
Rotary Switch Test	RANGE	For servicing purposes only. See 80 Series Service Manual
Data Output	HOLD H	Enable ultrasonic data transmission. (Beeper functions disabled)
Disable Beeper	))))	Turns off all beeper functions
High Input Impedance in mV DC	Hz	Provides >4000 MΩ input impedance for 400 mV dc range

⑮ **Analog Display**

The analog display is a 32-segment pointer that updates at a 40 times per second rate and is the best display to use for readings that are changing. It does not operate in the Capacitance or Frequency Counter functions or in the Peak MIN MAX mode.

For increased sensitivity, the analog pointer moves across the scale four times for each range. The pointer returns to 0 (wraps around) when the equivalent digital display reaches 1024, 2048, and 3072 counts. Select the next higher range if the pointer is too sensitive.

The analog pointer indicates a value lower than the digital display (up to 2.5% of range). Examples on the 40V range are:

Digital Display	= 5.00V	15.00V	25.00V	35.00V
Analog Pointer	= 4.8	4.5	4.5	4.2
Wrap Indication	= First = 4.8V	Second 14.5V	Third 24.5V	Fourth 34.2V

With stable inputs, use the digital display for the best sensitivity and precision.

⑯
0
1
2
3
4
5
6
7
8
9
0
Analog Display Scale

Scale for each 1000 counts in the digital display.

⑰ ± Analog Display Polarity

Indicates the polarity of the input except in the Frequency Counter mode, when it indicates the polarity of the trigger slope (edge).

⑱ **4000 mV** **Input Range Annunciator**

Displays 4, 40, 400, or 4,000 input range for volts, amps, or ohms, and 400 mV.

⑲ **OL** **Overload Indication**

Displayed on digital display when input (or math calculation in REL mode) is too large to display. If you are taking duty cycle readings, OL is displayed if the input signal stays high or low. All segments are illuminated on analog display.

Items 20-23 describe annunciators that indicate the mode or state in which the meter is operating:

⑳ **AUTO** **Autorange**

Meter is in the autorange mode and will automatically select the range with the best resolution. Meter powers-on in autorange mode.

In the autorange mode, the meter ranges up at 4096 counts and ranges down at 360. When the meter is in the Manual Range mode, the overrange arrow is displayed until you manually select a range appropriate for the input value.

See item 9 for manual ranging.

㉑ 🔋 **Low Battery**

Meter is powered by a single 9V battery, with a → 400 typical life of ~~500~~ hours with an alkaline battery. At least 8 hours of battery life remain when 🔋 is first displayed. A battery check is taken between measurements.

㉒ ▬ **Negative Polarity**

Automatically indicates negative inputs. When REL is enabled, indicates negative results of math calculations.

㉓ ı)))) **Beeper**

Continuity test is enabled. See item 11 and Table 2.

Items 24 through 31 describe math function annunciators and the annunciators that indicate the units of the value displayed.

㉔ △ **Relative Mode**

The value displayed is the difference between the present measurement and the previously stored reading. See item 12.

㉕ **100 ms** **Normal Recording Speed in MIN MAX Recording Mode**

Input changes of 100 milliseconds or longer will be recorded. In the 1 s High Accuracy MIN MAX Recording Mode, the recording speed is 1 second.

1 ms **Peak MIN MAX Recording Mode**

Input changes of 1 millisecond or longer will be recorded.

㉖ **RECORD** **Minimum, Maximum, and Average Recording**

Readings are being recorded in the MIN MAX Recording mode. A maximum (MAX), minimum (MIN), or average (AVG) reading can be displayed.

㉗ **MAX** **Maximum Value in MIN MAX Recording Mode**

The value displayed is the maximum reading taken since the MIN MAX Recording mode was entered.

㉘ **MIN** **Minimum Value in MIN MAX Recording Mode**

The value displayed is the minimum reading taken since the MIN MAX Recording mode was entered.

㉙ **AVG** **Average Value in MIN MAX Recording Mode**

The value displayed is the true average of all readings taken since the MIN MAX Recording mode was entered.

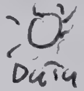
㉚ **🄷** **Hold**

The meter is operating in a Display Hold mode. See item 10 for Display Holds.

㉛ The following annunciators indicate the unit of the value displayed:

AC	Alternating current or voltage
DC	Direct current or voltage
V	Volts
mV	Millivolts (1 x 10^{-3} volts)
A	Ampere (amps). Current
mA	Milliampere (1 x 10^{-3} amps)
μA	Microampere (1 x 10^{-6} amps)
nS	Nanosiemens (1 x 10^{-9} siemens). Conductance (1/ohms).
%	Percent Annunciator (for duty cycle readings only)
Ω	Ohms. Resistance
kΩ	Kilohm (1 x 10^{3} ohms). Resistance
MΩ	Megohm (1 x 10^{6} ohms). Resistance
Hz	Hertz (1 cycle/sec). Frequency
kHz	Kilohertz (1 x 10^{3} cycles/sec). Frequency
μF	Microfarads (1 x 10^{-6} Farads). Capacitance
nF	Nanofarads (1 x 10^{-9} Farads). Capacitance

㉜



Not used

Holster and Flex-Stand

The meter comes with a snap-on holster that absorbs shocks and protects the meter from rough handling. The holster is equipped with a Flex-Stand. Some uses of the holster with Flex-Stand are shown in Figure 3.

APPLICATIONS

This section discusses some common applications for your meter, and alerts you to some considerations to keep in mind when taking measurements.

Measuring Voltage (AC/DC)

To measure voltage, connect the meter in parallel with the load or circuit under test. Each of the five ac/dc voltage ranges presents an input impedance of approximately 10 MΩ in parallel with less than 100 pF. Ac voltage is ac-coupled to the 10 MΩ input.

To improve the accuracy of dc voltage measurements made in the presence of ac voltages, measure the ac voltage first. Note the ac voltage range and manually select a dc voltage range that is the same or higher than the ac voltage range. This method improves the dc voltage accuracy by ensuring that the input protection circuits are not being activated. A typical application is measuring the dc offset voltage of an amplifier in the presence of an ac signal.

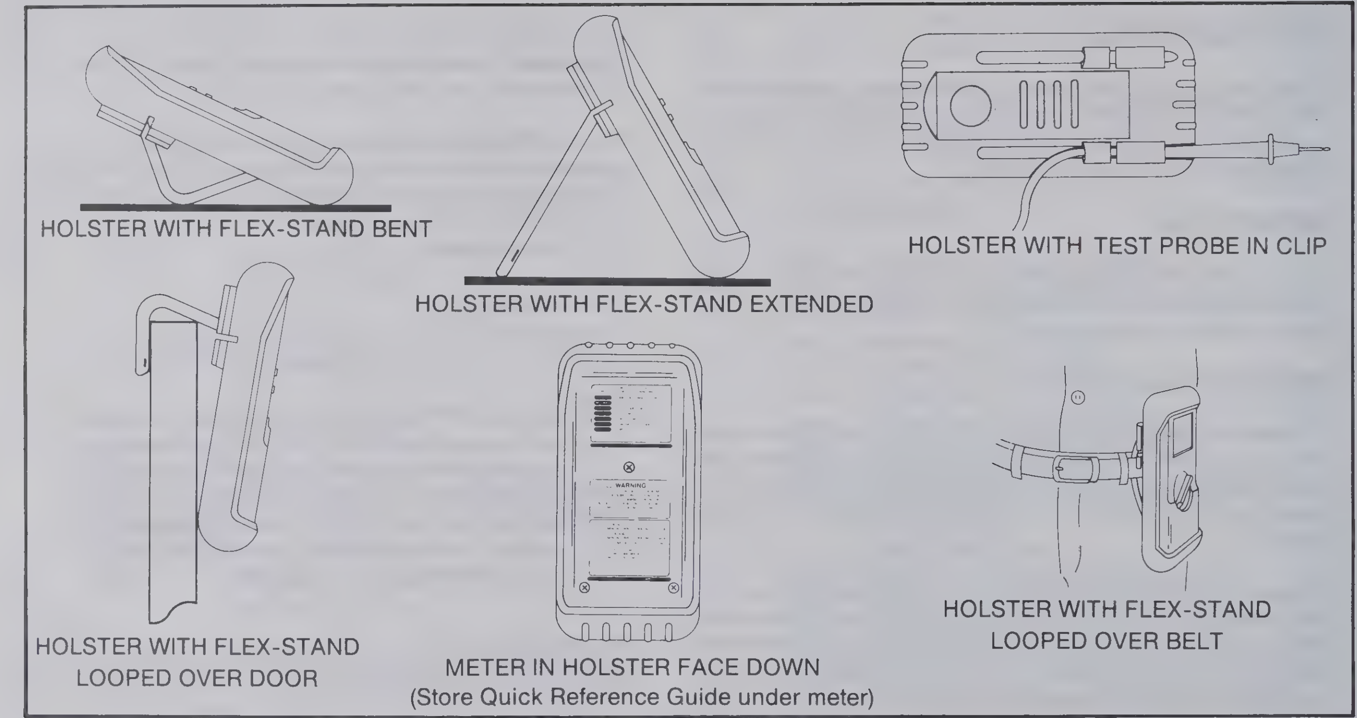
Measurement errors due to circuit loading can result when making either ac or dc voltage measurements on circuits with high source impedance. In most cases, the error is negligible (0.1% or less) if the measurement circuit source impedance is 10 kilohms or less.

Measuring Current

WARNING

DO NOT ATTEMPT AN IN-CIRCUIT CURRENT MEASUREMENT WHERE THE POTENTIAL IS GREATER THAN 600V. YOU MAY DAMAGE THE METER OR BE INJURED IF THE FUSE BLOWS WHILE CURRENT IS BEING MEASURED IN A CIRCUIT WHICH EXHIBITS AN OPEN CIRCUIT VOLTAGE GREATER THAN 600V.

To measure current, connect the meter in series with the load or circuit under test. Press the BLUE button to toggle between alternating and direct current.


HOLSTER WITH FLEX-STAND BENT

HOLSTER WITH FLEX-STAND EXTENDED

HOLSTER WITH TEST PROBE IN CLIP

HOLSTER WITH FLEX-STAND LOOPED OVER DOOR

METER IN HOLSTER FACE DOWN (Store Quick Reference Guide under meter)

HOLSTER WITH FLEX-STAND LOOPED OVER BELT

Figure 3. Holster and Flex-Stand

If you do not know approximately what the current is, connect the circuit to the A input terminal first to see if you have a safe level for the mA µA input terminal. Use the mA µA input terminal for current up to 400 mA.

When measuring current, the meter's internal shunt resistors develop a voltage across the meter's terminals called "burden voltage." This voltage drop is very low in your meter, but it may affect precision circuits or measurements.

To calculate the burden voltage: in A, multiply the display reading by 0.03V; in mA, multiply the display reading by 1.5 mV; in µA, multiply the display reading by 100 µV. For example, at a 20 mA display reading, the burden voltage is 20.00 x 1.5 mV = 30 mV.

The approximate resistance between the input terminals is 0.03 ohms for A, 1.5 ohms for mA, and 100 ohms for µA.

Continuity Testing

Continuity testing verifies that circuit connections are intact. To perform audible continuity tests, set the rotary switch to ·))) Ω ⊣⊢, press the (·)))) button, and connect the meter to your circuit. Test resistances below the values listed in Table 2 cause the meter to emit a continuous tone. Use the 400 ohm range for most wiring checks.

The continuity mode is extremely fast and can be used to detect either shorts or opens that last for as little as 1 millisecond. When a change is detected, the beeper tone is "stretched" to last at least ¼ second so you can hear it and detect both shorts and opens. This can be a valuable troubleshooting aid when looking for intermittents associated with cables, connections, switches, relays, etc. If the test value is very close to the threshold, erratic beeps can also occur due to environmental electrical noise (EMI).

Measuring Resistance

CAUTION

Turn off power on the test circuit and discharge all capacitors before attempting in-circuit resistance measurements. If an external voltage is present across a component, it will be impossible to take an accurate measurement of the resistance of that component.

The meter measures resistance by passing a known current through the external circuit or component, measuring the voltage drop, and calculating the resistance using Ohm's Law (Ω=V/A). Remember, the resistance displayed by the meter is the total resistance through all possible paths between the probes. This explains why in-circuit measurement of resistors does not often yield the ohms value indicated by the resistor's color code.

The resistance in the test leads can diminish accuracy on the lowest (400-ohm) range. The error is usually 0.1 to 0.2 ohms for a standard pair of test leads. To determine the error, short the test leads together and read the resistance of the leads. Use the Relative (REL) mode to automatically subtract the lead resistance from resistance measurements.

When measuring resistance, be sure that the contact between the probes and the circuit under test is good. Dirt, oil, solder flux, or other foreign matter seriously affect resistance.

Most in-circuit resistance measurements can be made without removing diodes and transistors from the circuit. The full-scale measurement voltage produced on ranges below 40 MΩ does not forward-bias silicon diodes or transistor junctions enough to cause them to conduct. Use the highest range you can (except 40 MΩ) to minimize the possibility of turning on diodes or transistor junctions. Full-scale measurement voltage in the 40-MΩ range does forward-bias a diode or transistor enough to cause it to conduct.

In resistance (and all other functions except current), the mA μA input is connected to a 1-kilohm resistor. If the mA μA input protection fuse is good, this input can be used as a partial check of proper operation in resistance. The input receptacles have split contacts; touch the probe to the half nearest the LCD. The 1-kilohm resistor is protected by a 3-diode clamp. Do not apply external voltage; it may blow the fuse.

Using Conductance for High Resistance or Leakage Tests

Conductance is the inverse of resistance (i.e., 1/ohms) and is measured in units of nanosiemens (nS = 1×10^{-9} Siemens). The 40-nS range on your meter effectively extends the resistance measurement capability to 100,000 MΩ. The 40-nS range can, therefore, be used to test the resistance or leakage in insulators, diodes, transistors, cables, connectors, printed circuit boards, transformers, motors, capacitors, or other high resistance components.

✓ To measure conductance, set the rotary switch to ~~(→+)~~, and Ω ⊣⊢ press (RANGE) to manually increment to the 40-nS range. Plug the test leads into the VΩ→+ and COM input terminals, and then connect these leads across the unit under test. The reading displayed is in units of conductance (nS). To convert this reading to megohms, divide the reading into 1000 (1000/displayed reading in nS = MΩ). For example 2.00 nS converts to 500 MΩ (1000/2.00). High value resistance measurements are susceptible to induced noise and may require careful shielding. To smooth out most noisy readings, enter the MIN MAX Recording mode and scroll to the average (AVG) reading.

NOTE

In the conductance range, there is normally a small residual reading with open test leads. To ensure accurate measurements, connect clean test leads to the meter and (with the leads open) read the residual leakage in nanosiemens. Correct subsequent measurements by using the Relative mode (REL) to zero the display, which subtracts the residual from the readings.

Diode leakage tests require that the diode junction be reverse-biased when being measured. To do this, connect the anode of the diode to the COM input terminal and the cathode (ring) of the diode to the VΩ→+ input terminal. Leakage at the test voltage being applied can then be read in terms of conductance.

High-voltage, stacked diode, assemblies can usually be tested for forward and reverse resistance changes using conductance. These assemblies typically have such high forward voltage drops that the diode test or resistance modes cannot test them.

Noisy Resistance Measurements

Your Fluke meter is designed to tolerate up to several volts of ac noise. Noise appears as changing numbers on the digital display and as an oscillating analog display. Changing the range may reduce the noise. To smooth out the effect of noise on your readings, enter the MIN MAX Recording mode and scroll to the average reading.

Measuring Capacitance

CAUTION

Turn off power and discharge the capacitor before attempting a capacitance measurement. Use the (V⎓) function to confirm that the capacitor is discharged.

The meter measures capacitance by charging the capacitor with a known current, measuring the resultant voltage, and calculating the capacitance. The measurement takes about 1 second per range (push button responses also take about 1 second). The capacitor charge can be up to 1.2V.

For measuring capacitor values up to 5.8µF, turn the rotary switch to ·))) Ω ⊣⊢, press the BLUE button, and connect the test leads to the capacitor. The meter will select the proper range automatically. Each measurement takes about 1 second per range. When making repeated measurements of similar values, press (RANGE) to manually select the proper range and to speed up subsequent measurements. For capacitors less than 5 nF or in noisy environments, use short test leads or a test fixture.

The measurement accuracy of capacitors less than 5 nF can be improved by first using the Relative mode to zero the display and automatically subtract the residual meter and test lead capacitance. Since the Relative mode also selects manual ranging, zero the residual capacitance only when measuring small value capacitors.

Residual voltage charges on the capacitor, or capacitors with poor insulation resistance or poor dielectric absorption may cause measurement errors.

To check capacitors larger than 5 μF, select Ω with the rotary switch (or press the BLUE button if you are in the capacitance mode). Select an appropriate range from Table 4. Discharge the capacitor, connect the capacitor to the meter, and time the number of seconds it takes for the charge to go from zero to full scale. At full scale, all of the analog display segments are on. To estimate the value of the capacitor, multiply the number of seconds times the charge rate (μF/sec) in Table 4. For example, a 10 μF capacitor takes about 33 seconds to charge in the 4 MΩ range or 3.3 seconds in the 400 kΩ range. To reconfirm your estimate, reverse the test leads; when the capacitor discharges to zero (the analog display polarity switches from - to +), start timing the recharge to full scale.

Diode Testing

To perform a diode or transistor junction test: plug the test leads into the VΩ→| and COM inputs, turn the rotary switch to →|, and connect the test leads across the diode(s).

In diode test, voltage is developed across the component(s) by a test current (approximately 1 mA with the test leads shorted) from the meter. Voltage is read on a single 0 to +3.000V range that can measure up to five silicon diode or transistor junctions in series. For a silicon diode, the typical forward voltage should be about 0.6V. Voltages greater than 3.00V or open test leads produce an overload (OL) reading. If the digital reading is the same in both directions, the diode junction is probably shorted. If the display reads OL in both directions, the diode junction is probably open. To protect sensitive devices, the open test lead voltage from the meter will not exceed 3.9V. Negative inputs (from an external power source, for example) are not suppressed.

Table 4. Approximate Charge Rate for Capacitors

Range	400Ω	4 kΩ	40 kΩ	400 kΩ	4 MΩ
μF/sec	3000	300	30	3	0.3

Use the Touch Hold mode (see item 10) to make audible diode tests. When the test leads are placed across the diode, a good diode or transistor junction will cause the meter to beep (and update the display) in the forward-biased direction and remain silent in the reverse-biased direction. A short or resistance below about 4000 ohms will cause a beep in both directions. If an open is detected, the meter will remain silent in both directions.

Using the Analog Display

The analog display is easy to use and interpret. It functions much the same as the needle on an analog meter without the mechanical overshoot inherent in needle movements.

The analog display is especially useful for peaking and nulling, and observing rapidly changing inputs. The analog display response time is fast, and it can be used to make approximate adjustments quickly. The 4000-count digital display can then be used for final adjustment.

The analog display can also be used for limited diagnostic purposes. In situations where rapidly fluctuating signal levels make the digital display useless, the analog display is ideal. Like the needle on a Volt-ohm-milliammeter (VOM), the analog display excels at displaying trends, or slowly changing signals. Many diagnostic routines using the analog display require practice. You will usually be looking for good or bad signal patterns that occur over some span of time. Noisy resistance measurements, for instance, create such patterns. Therefore, familiarity with analog display response and movement is necessary to accurately interpret a signal pattern. Compare the analog display response when making measurements on a unit known to be good, to the analog display response when making measurements on a faulty unit.

Using the MIN MAX Recording Mode

The MIN MAX Recording mode can be used to catch intermittents and turn on or turn off surges, verify performance, measure while you are away ("baby sit"), or take readings while you are operating the equipment under test and cannot watch the meter. The audible Min Max Alert indicates when a new minimum or maximum value has been recorded.

You can select either a 100 millisecond, 1 millisecond (Peak), or 1 second (high accuracy) "response time" for recording minimum and maximum readings. The response time is the length of time an input must stay at a new value to record the full change.

The 100 millisecond response time is best for recording power supply surges, inrush currents, and finding intermittent failures. This mode follows the update time of the analog display. (The minimum and maximum excursions of the analog display get recorded.)

The 1 millisecond Peak MIN MAX mode is ideal for recording transients, especially from intermittant power lines or connections. This mode can also be used to measure the + and - peak values of sinewaves up to about 450 Hz, for easy measurement of both peak line voltage and line current measurements of power supplies and electrical equipment.

The high accuracy mode (1 second response time) follows the digital display and can be selected as a power-on option by pressing (MIN MAX) while turning the meter on. This mode has the full accuracy of the meter and is best for recording power supply drift, line (mains) voltage changes, or circuit performance while line voltage, temperature, load, or some other parameter is being changed. *Frequency Counter readings are recorded only in the high accuracy mode.*

In the MIN MAX Recording mode, the true average of all readings taken since entering MIN MAX is calculated. The average value displayed in both the 100 millisecond and 1 second modes is the mathematical integral of the input (within the response time and accuracy specifications of the meter). When you display the average, the reading rate slows somewhat in order to calculate the average of the accumulated readings.

The average reading is useful for smoothing out unstable or changing inputs, calculating power consumption (such as kilowatt hours), estimating the percent of time a circuit is operational, or verifying circuit performance (or temperature with the optional 80TK Thermocouple Module).

If you want to record readings only during the duration of a particular test (such as during the frequency response sweep of an audio amplifier, for example), apply the input signal, start the test (or sweep, in this example), and let the meter stabilize. Now press (MIN MAX), then press (HOLD ▣), and stop the test. The minimum, maximum, and average of all readings taken during the test are now held in memory. Momentarily press (MIN MAX) to scroll to the reading of interest. Be careful: if you hold down the (MIN MAX) for longer than a second, you will exit the MIN MAX Recording mode and erase the memory. As long as the rotary switch is not turned and the other pushbuttons (except REL) are not pressed, these readings will remain in memory until the battery dies.

Measuring Frequency

In the Frequency Counter mode, the frequency display autoranges to one of five ranges: 199.99 Hz, 1999.9 Hz, 19.999 kHz, 199.99 kHz, and greater that 200 kHz. For frequencies below

10 Hz, the update rate slows and follows the input signal. For frequencies between 0.5 Hz and 0.3 Hz, the display may not be stable. For frequencies below 0.3 Hz, the display shows 0.000 Hz.

For most frequency measurements, turn the rotary switch to the Ṽ setting, connect the meter to the signal being measured, and then press Hz button. Connecting the meter to the signal before pressing Hz will normally allow the meter to autorange to an appropriate range, but the minimum input signal required to trigger the frequency counter varies, depending on the range and frequency (see Specifications). If the input signal is below the trigger level, frequency measurements will not be taken. If your readings are unstable, the input signal may be near the trigger level for that range. You can usually correct this by selecting a lower range. In the Frequency Counter mode, the range (displayed in the lower-right corner of the LCD) will only change when you press the RANGE button.

If your readings seem to be a multiple of what you expected, your input signal may have distortion or ringing. (For example, electronic motor controls distort both voltage and current waveforms.) Select a higher input range if you suspect multiple triggering. An alternative is to turn the rotary switch to the V̄ or mV̄ setting, which will shift the trigger level from 0V to a positive voltage that changes with each range. In general, the lowest frequency displayed is the correct one.

In the Frequency Counter mode, the input range acts like an attenuator, the Ṽ function ac-couples the input signal, and the V̄ and mV̄ functions dc-couple the input signal. The V̄ function is optimized for triggering on logic and switching signals. The 4V dc range is optimized to trigger on all common 5V logic families (triggers at 1.7V ± 0.1V). High frequency logic signals may require the use of the 400 mV ac range. The 40V dc range is optimized to trigger on automotive switching signals (triggers at 4V ± 1V). All ranges in the V̄ function trigger at approximately 10% of range, except for the 4V range.

Frequency measurements can be made on current inputs. The inputs are always dc-coupled. The triggering characteristics are shown in Table 5.

Table 5. Frequency Counter Operation With Current Inputs

INPUT RANGE	APPROXIMATE SENSITIVITY (0.5 Hz-20 kHz)	APPROXIMATE TRIGGER LEVEL	
		AC CURRENT	DC CURRENT
μA	300 μA	0 μA	400 μA
mA	30 mA	0 mA	40 mA
A	3A	0A	4A

Measuring Duty Cycle

Duty Cycle (or duty factor) is an alternate Frequency Counter mode that displays, in percent, the time the input signal is above the trigger level (or below the trigger level if the negative trigger slope is selected). The Duty Cycle mode is optimized for measuring the on or off time of logic or switching controls. Many industrial control systems (electronic fuel injection in automobiles, for example) are pulse-width modulated, and duty cycle measurements provide a quick check on their performance.

For logic level signals, use the 4V dc range. For 12V switching signals in automobiles, use the 40V dc range. For sine waves, use the most sensitive range you can without getting double triggering. (Normally, a clean signal can be up to ten times the amplitude of the range you are on.) Duty cycle measurements can also be used as an indication of potential triggering problems on sine wave or near sine wave signals. If you do not measure approximately 50% duty cycle, you may have a distorted waveform.

In Duty Cycle (and Frequency Counter) mode, the slope (or edge) on which the counter triggers is selected by pressing (ıııı). The slope selected is indicated by a + or - annunciator in the lower-left corner of the LCD. The waveform shown in Figure 4 represents the duty cycle measurement of a typical logic signal.

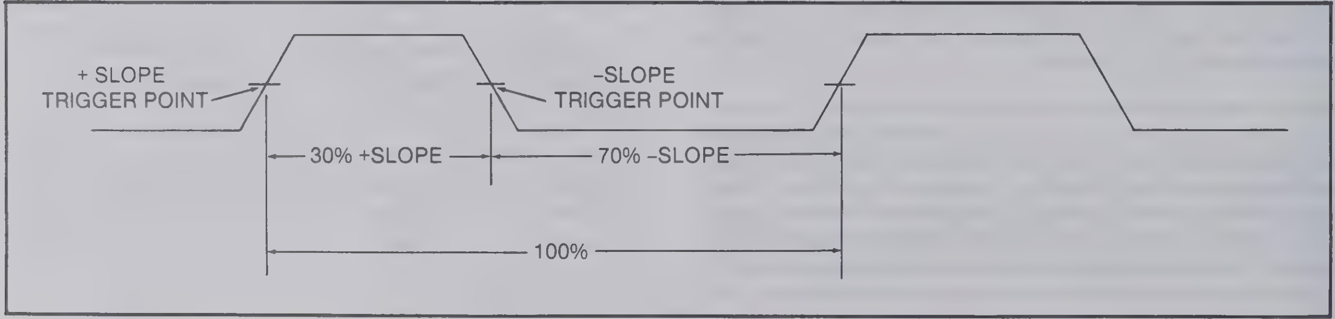


Figure 4. Duty Cycle Measurement of Typical Logic Signal

The manner in which your meter takes duty cycle measurements allows it to be very tolerant of aperiodic (repetitive but not periodic) signals. Duty cycle measurements on low frequency (<400 kHz) aperiodic logic signals, especially serial communication signals, is a simple form of signature analysis. A known pattern will read the same duty cycle every time (if the pattern repeats in less than 1/3 second).

The precision and resolution of the duty cycle measurements are achieved by averaging many repetitions of the input signal. In rare cases, this averaging technique (which is similar to pulse-width averaging in a conventional counter) may cause a measurement problem called "aliasing." Aliasing results when the frequency of the input signal happens to be exactly synchronized with the reference crystal oscillator of the meter. This occurs when the frequency of the input signal can be exactly divided into the frequency of the oscillator (131,072 Hz) or one of the oscillator's harmonics. When they are nearly synchronized, the meter is "blind" to the correct duty cycle, and the display will alternate between incorrect readings. If this occurs, and the frequency reading was stable, press (MIN MAX) to select the MIN MAX Record mode and scroll to the average display. The average display will stabilize on the correct duty cycle.

A common duty cycle measurement is the "dwell" angle in an automobile. Dwell is the number of degrees of distributor rotation that the points remain closed (or current is flowing in the coil). Use the following to convert a dwell angle to duty cycle (in percent):

$$\%\ \text{Duty Cycle} = \frac{\text{Dwell (degrees)} \times \text{No. of Cylinders} \times 100}{360\ \text{degrees}}$$

To make a dwell measurement, set the rotary switch to $\overline{\text{V}}$, select the 40V range, press (Hz) twice (the % annunciator on the right side of the LCD should turn on), and press the (·)))) (to select the negative trigger slope so the measurement will be the "off" or points closed time). Then connect the COM input to ground, and connect the VΩ→+ input to the low (or switched) side of the coil. Most automobiles have the points closed for a duty cycle between 50-70%.

Pulse Width Measurements

For a periodic waveform (that is, repetitive at equal time intervals), a duty cycle measurement can be easily converted to pulse width. First measure the frequency and then measure the duty cycle. Toggle (·)))) to select the polarity of the pulse you want to measure. To convert frequency and duty cycle measurements into a pulse width, use the following:

$$\text{Pulse Width} = \frac{\%\ \text{Duty Cycle}/100}{\text{Frequency}}$$

MAINTENANCE

Repairs or servicing not covered in this manual should only be performed by qualified personnel as described in the 80 Series Service Manual (P/N 834168).

General Maintenance

Periodically wipe the case with a damp cloth and detergent; do → not use abrasives or solvents.

Calibration

Calibrate your meter once a year to ensure that it performs according to its specifications. Contact the nearest Service Center or refer to the 80 Series Service Manual for calibration procedures. For replacement parts, see the parts list at the end of this manual.

WARNING

TO AVOID ELECTRICAL SHOCK, REMOVE THE TEST LEADS AND ANY INPUT SIGNALS BEFORE REPLACING THE BATTERY OR FUSES. TO PREVENT DAMAGE OR INJURY, INSTALL ONLY QUICK ACTING FUSES WITH THE AMP/VOLT RATINGS SHOWN IN FIGURE 5.

Battery Replacement

The meter is powered by a single 9V battery (NEDA 1604, 6F22, or 006P). Referring to Figure 5, use the following procedure to replace the battery:

1. Disconnect test leads from any live source, turn the rotary switch to OFF, and remove the test leads from the front terminals.

2. The case bottom is secured to the case top by three screws and two internal snaps (at the LCD end). Using a Phillips-head screwdriver, remove the three screws from the case bottom and turn the case over.

3. Lift the input terminal end of the case top until it gently unsnaps from the case bottom at the end nearest the LCD.

4. Lift the battery from the case bottom, and carefully disconnect the battery connector leads.

5. Snap the battery connector leads to the terminals of a new battery and reinsert the battery into the case bottom. Dress the battery leads so that they will not be pinched between the case bottom and case top.

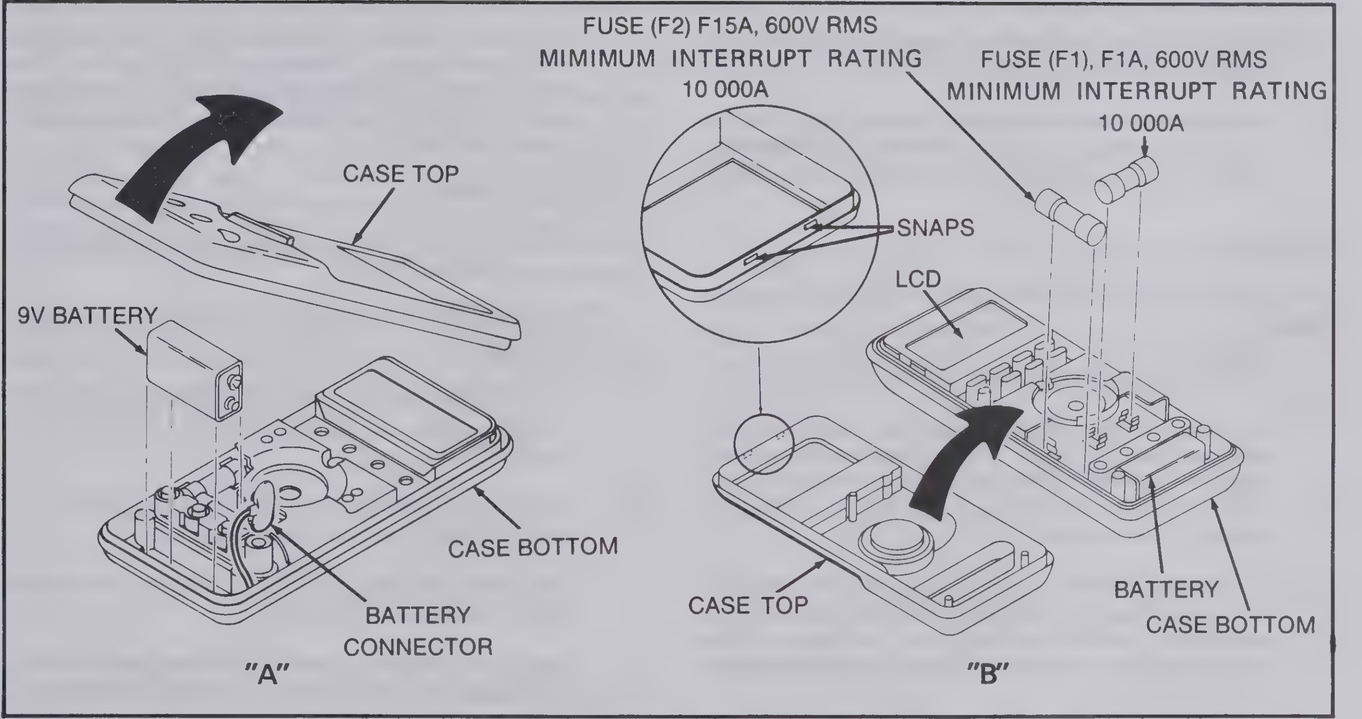

FUSE (F2) F15A, 600V RMS
MIMIMUM INTERRUPT RATING
10 000A
FUSE (F1), F1A, 600V RMS
MINIMUM INTERRUPT RATING
10 000A
CASE TOP
SNAPS
LCD
9V BATTERY
CASE BOTTOM
BATTERY CONNECTOR
CASE TOP
BATTERY
CASE BOTTOM
"A"
"B"

Figure 5. Battery and Fuse Replacement

6. Ensure that the case top rotary switch and circuit board switch are in the OFF position.

7. Replace the case top, ensuring that the gasket is properly seated and the two snaps on the case top (at the end near the LCD) are engaged. Reinstall the three screws.

Fuse Test

Use the following procedure to test the internal fuses of the meter.

1. Turn the rotary selector switch to ·))) Ω ⊣⊢.

2. Plug a test lead into the VΩ▶| input terminal and touch the probe to the A input terminal. Because the receptacles of the input terminals contain split contacts, be sure that you touch the probe to the half of the receptacle contact that is nearest the LCD.

3. The display should indicate between 00.0 and 00.5 ohms. This tests F2 (15A, 600V). If the display reads OL (overload), replace the fuse and test again. If the display reads any other value, have the meter serviced.

4. Move the probe from the A input terminal to the mA μA input terminal.

5. The display should indicate between 0.995 kilohms and 1.005 kilohms. This tests F1 (1A, 600V). If the display reads OL (overload), replace the fuse and test again. If the display reads any other value, have the meter serviced.

Fuse Replacement

Referring to Figure 5, use the following procedure to examine or replace the meter's fuses:

1. Perform steps 1 through 3 of the battery replacement procedure.

2. Remove the defective fuse by gently prying one end of the fuse loose and sliding the fuse out of the fuse bracket.

3. Install a new fuse of the same size and rating. Make sure the new fuse is centered in the fuse holder.

4. Ensure that the case top rotary switch and circuit board switch are in the OFF position.

5. Replace the case top, ensuring that the gasket is properly seated, the battery leads are properly dressed, and the two snaps on the case top (at the end near the LCD) are engaged. Reinstall the three screws.

Service

If the meter fails, check the battery and fuse(s) and replace as needed. If the meter still does not work properly, review this manual to make sure you are operating it correctly. If the meter still malfunctions, pack it securely in its original shipping container and forward it, postage paid, to the nearest Service Center. Include a description of the malfunction. Fluke assumes NO responsibility for damage in transit.

A meter under warranty will be promptly repaired or replaced (at Fluke's option) and returned at no charge. See the registration card for warranty terms. If the warranty has lapsed, the meter will be repaired and returned for a fixed fee. Contact the nearest Service Center for information and prices. A list of U.S. and international service centers is at the back of this manual.

REPLACEMENT PARTS

NOTE

⚠ ▣ *When servicing the meter, use only the replacement parts specified.*

Replacement parts are shown in Figure 6 and listed in Table 6. To order replacement parts in the USA, call 1-800-526-4731. To order outside the USA, contact the nearest Service Center.

REPLACEMENT PARTS

Table 6. Replacement Parts

ITEM	DESCRIPTION	FLUKE PART NUMBER	QUANTITY
BT1	Battery, 9V	614487	1
F1*	Fuse, F1A, 600V RMS	830828	1
F2	Fuse, F15A, 600V RMS	820829	1
H1	Screw, Case	832246	3
H2	Gasket, Case	826198	1
MP1	Foot, Non-Skid	824466	2
MP2	O-Ring, Input Receptacle	831933	1
TM1	User's Manual, Fluke 87 (English)	834192	1
TM2	User's Manual, Fluke 87 (International)	834200	—
TM3	Service Manual, Fluke 80 Series	834168	—
TM4	Quick Reference Guide, Fluke 80 Series	844290	1
TL20**	Industrial Test Lead Set (Optional)		—
TL70**	Test Lead Set		1
C81Y**	Holster, Yellow		1
C81G**	Holster, Gray (Optional)		—
C25**	Carrying Case, Soft (Optional)		—

* *To ensure safety, use Bussman BBS-1 or Fluke 830828 only.*

** *Items marked with two asterisks are Fluke accessories and are available from your authorized Fluke/Philips distributor.*

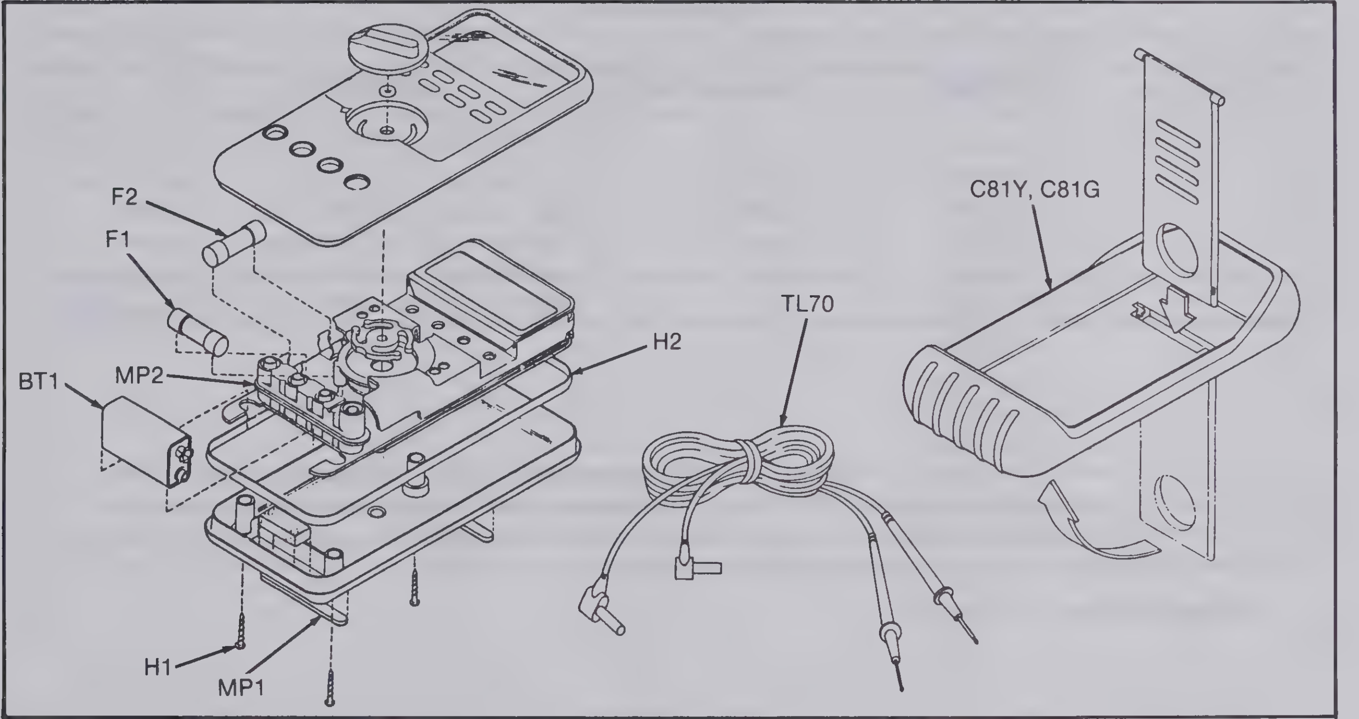

F2
F1
BT1
MP2
H2
H1
MP1
TL70
C81Y, C81G

Figure 6. Replaceable Parts

Specifications

FUNCTION	RANGE	RESOLUTION	ACCURACY*		
			50 Hz-60 Hz	45 Hz-5 kHz	5 kHz-20 kHz**
$\tilde{V}$	400.0 mV	0.1 mV	±(0.7% + 4)	±(1.0% + 4)	±(2.0% + 4)
	4.000V	0.001V	±(0.7% + 2)	±(1.0% + 4)	±(2.0% + 4)
	40.00V	0.01V	±(0.7% + 2)	±(1.0% + 4)	±(2.0% + 4)
	400.0V	0.1V	±(0.7% + 2)	±(1.0% + 4)	±(2.0% + 4)
	1000V	1V	±(0.7% + 2)	±(1.0% + 4)**	Unspecified

* *Accuracy is given as ±([% of reading] + [number of least significant digits]) at 18° C to 28° C, with relative humidity up to 90%, for a period of one year after calibration. In the 4½-digit mode, multiply the number of least significant digits (counts) by 10. AC conversions are ac-coupled, true rms responding, calibrated to the rms value of a sine wave input, and valid from 5% to 100% of range. AC crest factor can be up to 3 at full scale, 6 at half scale.*

***Below 10% of range, add 16 counts.*

Specifications (cont)

FUNCTION	RANGE	RESOLUTION	ACCURACY
⎓V	4.000V	0.001V	±(0.1% + 1)
	40.00V	0.01V	±(0.1% + 1)
	400.0V	0.1V	±(0.1% + 1)
	1000V	1V	±(0.1% + 1)
⎓mV	400.0 mV	0.1 mV	±(0.1% + 1)
Ω	400.0Ω	0.1Ω	±(0.2% + 1)
	4.000 kΩ	0.001 kΩ	±(0.2% + 1)
	40.00 kΩ	0.01 kΩ	±(0.2% + 1)
	400.0 kΩ	0.1 kΩ	±(0.2% + 1)
	4.000 MΩ	0.001 MΩ	±(0.2% + 1)
	40.00 MΩ	0.01 MΩ	±(1% + 3)
(nS)	40.00 nS	0.01 nS	±(1% + 10)

Specifications (cont)

FUNCTION	RANGE	RESOLUTION	ACCURACY***
Capacitance	5.00 nF	0.01 nF	±(1% + 35)†
	0.0500 μF	0.0001 μF	±(1% + 2)
	0.500 μF	0.001 μF	±(1% + 2)
	5.00 μF	0.01 μF	±(1% + 2)
Diode Test	3.000V	0.001V	±(2% + 1)

FUNCTION	RANGE	RESOLUTION	ACCURACY	BURDEN VOLTAGE Maximum
mA A ~ (45 Hz to 2 kHz)	40.00 mA	0.01 mA	±(1.0% + 2)	1.5 mV/mA
	400.0 mA	0.1 mA	±(1.0% + 2)	1.5 mV/mA
	4000 mA	1 mA	±(1.0% + 2)	0.03 V/A
	10.00A††	0.01A	±(1.0% + 2)	0.03 V/A
mA A ⎓	40.00 mA	0.01 mA	±(0.2% + 2)	1.5 mV/mA
	400.0 mA	0.1 mA	±(0.2% + 2)	1.5 mV/mA
	4000 mA	1 mA	±(0.2% + 2)	0.03 V/A
	10.00A††	0.01A	±(0.2% + 2)	0.03 V/A

*** *With film capacitor or better*

† *±(1% + 2) if Relative mode is used to zero residual*

†† *10A continuous, 20A for 30 seconds maximum*

Specifications (cont)

Maximum

FUNCTION	RANGE	RESOLUTION	ACCURACY	BURDEN VOLTAGE
$\widetilde{\mu A}$	400.0 μA	0.1 μA	±(1.0% + 2)	100 μV/μA
(45 Hz to 2 kHz)	4000 μA	1 μA	±(1.0% + 2)	100 μV/μA
$\overline{\mu A}$	400.0 μA	0.1 μA	±(0.2% + 2)	100 μV/μA
	4000 μA	1 μA	±(0.2% + 2)	100 μV/μA

FUNCTION	RANGE	RESOLUTION	ACCURACY
Frequency	199.99	0.01 Hz	±(0.005% + 1)
(0.5 Hz to 200 kHz,	1999.9	0.1 Hz	±(0.005% + 1)
pulse width	19.999 kHz	0.001 kHz	±(0.005% + 1)
>2 μs)	199.99 kHz	0.01 kHz	±(0.005% + 1)
	>200 kHz	0.1 kHz	Unspecified

Specifications (cont)

FREQUENCY COUNTER SENSITIVITY AND TRIGGER LEVEL

INPUT RANGE	MINIMUM SENSITIVITY (RMS SINEWAVE)		APPROXIMATE TRIGGER LEVEL (DC VOLTAGE FUNCTION)
(Maximum input for specified accuracy = 10X Range or 1000V)	5 Hz-20 kHz	0.5 Hz-200 kHz	
400 mV dc	70 mV (to 400 Hz)	70 mV (to 400 Hz)	40 mV
400 mV ac	150 mV	~~100~~ mV (150)	—
4V	0.3V	0.7V	1.7V
40V	3V	7V	4V
400V	30V	70V (≤140 kHz)	40V
1000V	300V	700V (≤14 kHz)	400V

Duty Cycle 0.0 to 99.9%

Accuracy: Within ±(0.05% per kHz + 0.1%) of full scale for a 5V logic family input on the 4V dc range.

Within ±((0.06 x Voltage Range/Input Voltage) x 100%) of full scale for sine wave inputs on ac voltage ranges.

Specifications (cont)

FUNCTION	OVERLOAD PROTECTION†	INPUT IMPEDANCE (nominal)	COMMON MODE REJECTION RATIO (1 kΩ unbalance)	NORMAL MODE REJECTION
⎓V	1000V rms	10 MΩ<100 pF	>120 dB at dc, 50 Hz or 60 Hz	>60 dB at 50 Hz or 60 Hz
⎓mV	1000V rms	10 MΩ<100 pF	>120 dB at dc, 50 Hz or 60 Hz	>60 dB at 50 Hz or 60 Hz
~V	1000V rms	10 MΩ<100 pF (ac-coupled)	>60 dB, dc to 60 Hz	

		OPEN CIRCUIT TEST VOLTAGE	FULL SCALE VOLTAGE		SHORT CIRCUIT CURRENT
			To 4.0 MΩ	40 MΩ or nS	
Ω	1000V rms ††	<1.3V dc	<450 mV dc	<1.3V dc	<500 μA
Diode Test	1000V rms ††	<3.9V dc	3.000V dc		1.0 mA typical

† *10^7 V Hz max*

†† *For circuits < 0.3A short circuit, 660V for high energy circuits.*

Specifications (cont)

	NOMINAL RESPONSE	ACCURACY
MIN MAX Recording	100 ms to 80%	Specified accuracy ±12 digits for changes >200 ms in duration (±40 digits in AC)
	1 s	Same as specified accuracy for changes >2 seconds in duration
	1ms	Specified accuracy +/- 40 digits for changes >1 ms in duration. (+/- 100 digits typical for mV, 400 μA dc, 40 mA dc, 4000 mA dc).

FUSE PROTECTION	
mA or μA	1A 600V FAST Fuse
A	15A 600V FAST Fuse

MAXIMUM VOLTAGE BETWEEN ANY TERMINAL AND EARTH GROUND
1000 Volts

Specifications (cont)

Display	Digital: 4000 counts, updates 4/sec 19,999 counts (4 ½-digit mode), updates 1/sec Analog: 4 x 32 segments (equivalent to 128), updates 40/sec Frequency: 19,999 counts, updates 3/sec @ > 10 Hz Backlight: On for 68 seconds when selected.
Operating Temperature	-20°C to 55°C
Storage Temperature	-40°C to 60°C
Temperature Coefficient	0.05 x (specified accuracy)/°C (<18°C or >28°C)
Relative Humidity	0% to 90% (0°C to 35°C) 0% to 70% (35°C to 55°C)
Battery Type	9V, NEDA 1604 or 6F22 or 006P
Battery Life	400 hrs typical with alkaline
Shock, Vibration	Per MIL-T-28800 for a Class 2 Instrument
Size (HxWxL)	1.25 in x 3.41 in x 7.35 in (3.1 cm x 8.6 cm x 18.6 cm)
With Holster and Flex-Stand:	2.06 in x 3.86 in x 7.93 in (5.2 cm x 9.8 cm x 20.1 cm)
Weight	12.5 oz (355g)
With Holster and Flex-Stand:	22.0 oz (624g)
Safety	Designed to Protection Class II per IEC 348, ISA-DS82, and UL1244

SERVICE CENTERS

U.S.A.

John Fluke Mfg. Co.
Fremont, CA 94538
TEL: (415) 651-5112

John Fluke Mfg. Co.
Palatine, IL 60067
TEL: (312) 705-0500

John Fluke Mfg. Co.
Paramus, NJ 07652
TEL: (201) 599-9500

John Fluke Mfg. Co.
Everett, WA 98203
TEL:(206) 356- 556 0

INTERNATIONAL

Argentina, Buenos Aires
Coasin S.A.
TEL: 54-1-522-5248 or 3485
TLX: (390) 22284 COASN AR

Australia, Moorebank
N.S.W. PCS Service
TEL: 61-2-602-2000

Australia, North Ryde
N.S.W. PCS Service I&E
TEL: 61-2-888-0440

Austria, Vienna
Oesterreichische Philips Industrie
GmbH Triesterstrasse
66 A-1101 Wien, Austria

Belgium, Brussels
Philips & MBLE Associated S.A.
TEL: 46-8-7821000 TLX:
TX61511.PHEMB BEL/BRMS

Brazil, Sao Paulo
Hi-Tek Electronica Ltda
TEL: 55-11-421-5477
TLX: (391) (011) 71413 HITK BR

Bolivia, La Pas
Coasin Bolivia S.R.L.
Tel: 591- 2- 40962
TLX: (336) 3233 COALAPBV

Canada, Ontario
Fluke Electronics Canada Inc.
TEL: (416) 890-7600

Chile, Santiago
Intronica Chile Ltda.
TEL: 56-2-2321886, 2324308
TLX: (332) 346351 INTRON CK

Colombia, Bogota
Sistemas E Instrumentacion, Ltda
TEL: 57-232-4532
TLX: (396) 45787 COASN CO

Denmark, Kobenhavn
Philips A/S Test and Measurement
TEL: 45-1-572222
TLX: 31201

Ecuador, Quito
Proteco Coasin Cia., Ltda.
TEL: 593-2-529684 or 526759
TLX: (393) 22085 ESIND

Egypt, Cairo
Philips Egypt Liaison Office
TEL: 20-2-3490922
TLX: 22816 PHEGY UN

Federal Republic of Germany
Philips GmbH Unternehmensbereich
Elecktronik fur Wissenschaft und Industrie TEL: 89-96050
TLX: 0522472

Finland, Espoo
Instrumentarium Elektroniikka
TEL: 358-0-52781
TLX: 121875

France, Bobigny
S.A. Philips Industrielle et Commerciale,
Science et Industry
TEL: 33-1-4942-8000
TLX: 210290 F - INDUTHI

Greece, Athens
Philips S.A. Hellenique, I &E Division
TEL: 30-1-4894911
TLX: (863) 219330

Hong Kong
Schmidt & Co. (H.K.) Ltd
TEL: 852-5-8330222
TLX: (780) 76762 SCHMC HX

India, Bombay
Hinditron Services Pvt. Ltd
TEL: 6300043 or 6300527
TLX: (953) 11-72247 HEMC IN

India, Bangalore
Hinditron Services Pvt. Ltd
TEL: 91-812-363139
TLX: (953) 845741 HSPL IN

India, New Dehli
Hinditron Services Pvt. Ltd
TEL: 011-6433675
TLX: (953) 031-61458 HCPL IN

India, Secunderabad
Hinditron Services Pvt. Ltd
TEL: 08-42-821117
TLX: (953) 425-6973

Israel, Tel Aviv
R.D.T. Electronics Engr., Ltd
TEL: 972-3-483211
TLX: (922) 371452 RDT IL

Italy, Monza
Philips S.P.A.
TEL: 39-2-6181893
TLX: (843) 334643 SISTRL

Indonesia, Jakarta
P.T. Lamda Triguna
TEL: (021) 8195365
TLX: 46171 LAYAR IA

Japan, Tokyo
John Fluke Mfg. Co, Inc.
TEL: 81-3-434-0181
TLX: (781) 2424331 FLUKJPJ

Korea, Seoul
Myoung Corporation
TEL: 82-2-784-9942
TLX: K24283 MYOUNG

Malaysia, Selangor
Mecomb Malaysia Sdn. Bhd
TEL: 60-3-7743422
TLX: (784) MA37764 MECOMB

Mexico, Mexico City
Mexicana de Electronica Industrial,
S.A. (MEXEL)
TEL: 90-5-660-4323
TLX: (383) 1771038 FAIRME

Netherlands, Tilburg
Philips Nederland Business Unit:
Test & Meetapparaten
TEL: 013-35-24-55
TLX: 52683

New Zealand, Auckland
Philips New Zealand, Ltd
TEL: 64-4-735-735
TLX: NZ3391

Norway, Oslo
Morgenstierne & Co. A/S
TEL: 47-2-356-110
TLX: 856 71719

Pakistan, Karachi
International Operations (PAK), Ltd
TEL: 92-21-221127, 239052
TLX: (952) 24494 PIO PK

Peru, Lima
Importaciones & Representaciones
Electronicas S.A.
TEL: 51-14-288650
TLX: (394) 25663 PE IREING

Philippines, Manila
Spark Radio & Electronics Inc.
TEL: 63-2-775192
TLX: (722) 27901 RLA PH

Portugal, Lisbon
Decada Espectral Equipamentos de
Electronica e Cientificos, SARL
TEL: 351-1-4103420
TLX: (832) 15515

Republic of Singapore
Rank O'Connor's Singapore (PTE) Ltd
TEL: 65-4737944
TLX: OCONSIN RS21023

Spain,Madrid
Philips Iberica S.A.E. Depto.
Tecnico Instrumentacion
C/Martinez Villergas 2 28027
Madrid, Spain

Republic of South Africa, Johannesburg
South African Philps, (Pty) Ltd
TEL: 27-11-470-5255
TLX: 296641 PIELYCG

Sweden, Stockholm
Philips Forsaljning AB
TEL: 46-8-7821000
TLX: 14060 TLXC SEDSHIE

Switzerland, Zurich
Philips AG
TEL: 41-1-488-2211
TLX: 815 780 11

Taiwan, Taipei
Schmidt Electronics Corp.
TEL: 886-2-501-3468
TLX: (785) 11111 SCHMIDT

Thailand, Bangkok
Measuretronix Ltd
TEL: 66-2-3742516, 3741632
TLX: (788) 82796 HUAMARK TH

Turkey, Istanbul
Turk Philips Ticarel A.B.
TEL: 90-1-1435910
TLX: 24192 PHTRTR

United Kingdom, Watford, Herts
Philips Scientific Test & Measuring
Division
TEL: 0923-240511
TLX: 934583

Uruguay, Montevideo
Coasin Uruguaya S.A.
TEL: 598-2-789015
TLX: (398) COAUR UY23010

Venezuela, Caracas
Coasin C.A.
TEL: 58-2-241-0309, 241-1248
TLX: (395) 21027 EMVEN VC

ERRATA #3

On page 8, under item 8, add the following to the second paragraph, second sentence as follows:

A continuous beeper tone is emitted when an overload is recorded. ✓

ERRATA #4

On page 12, under item 12, change the first paragraph as follows:

CHANGE: ...... The relative mode annunciator (-) is displayed. .... ✓
TO: ...... The relative mode annunciator (Δ) is displayed. .... ✓

On page 15, under Item 21,

CHANGE: Meter is powered by a single 9V battery, with a typical life of 500 hours with an alkaline battery. ✓

TO: Meter is powered by a single 9V battery, with a typical life of 400 hours with an alkaline battery. ✓

ERRATA #5

On page 20, under "Using Conductance for....", change the second paragraph as follows:

FROM: To measure conductance, set the rotary switch to •))) , ... ✓
TO: To measure conductance, set the rotary switch to Ω ⊣⊢, ... ✓

CHANGE #1 - 38541

On page 28, under General Maintenance, replace the first paragraph with the following:

> Periodically wipe the case with a damp cloth and detergent; do not use abrasives or solvents. If the input alert is falsely activated by moisture:
>
> 1. Turn the multimeter off and remove all test leads.
> 2. Shake out the input receptacles.
> 3. Use a clean swab in each of the four terminals to dislodge and clean out the contamination.
> 4. Soak a new swab with the cleaning and oiling agent WD40. Work this swab around in the A and mA uA terminals. Since the oiling agent insulates the terminals from moisture-related shorting, this preventive treatment ensures against future erroneous Input Alerts.

ERRATA #6

On page 38, under Specifications (cont), change the following:

FROM:	400 mV ac	150 mV	100 mV	-	✓
TO:	400 mV ac	150 mV	150 mV	-	✓

ERRATA #7

On page 42, under U.S.A., change the following:

FROM: John Fluke Mfg. Co.
Everett, WA 98203
TEL:(206) 356-556

TO: FROM: John Fluke Mfg. Co. ✓
Everett, WA 98203
TEL:(206) 356-5560

ERRATA #8

On page 34, add the following under *Accuracy......,

For non-sinusoidal wave forms add -(2%Rdg + 2% Fs) typical, for a crestfactor up to 3.

ERRATA #9

On page 11, under Power-On Option: Ultrasonic Data Output,

CHANGE: This mode is used during the manufacturing and service of your meter.

TO: This mode is used during the manufacturing and service of your meter and cannot be modified for customer use.

Under Table 3, under FUNCTION,

CHANGE: Enable ultrasonic data transmission. (Beeper functions disabled)

TO: Enable ultrasonic data transmission. (For use in factory testing only, cannot be modified for customer use. Beeper functions disabled.)

On page 16, under item 31,

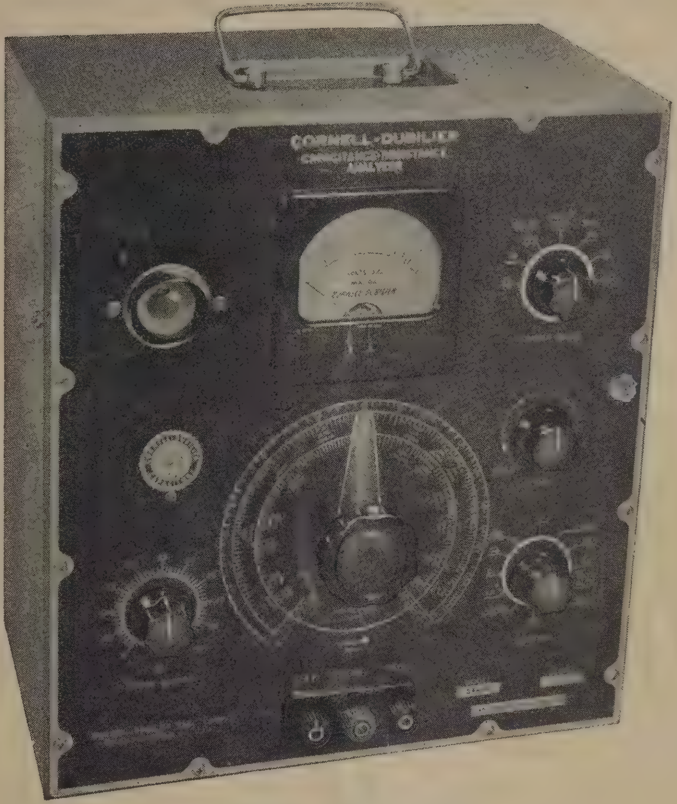
ADD:	㉜	☼	Not Used
		Duty	Not Used

ERRATA #10

On pages 36 and 37,

CHANGE: BURDEN VOLTAGE ✓
TO: MAXIMUM BURDEN VOLTAGE ✓

OPERATING INSTRUCTIONS



Cornell - Dubilier

De Luxe

CAPACITANCE - RESISTANCE ANALYZER

MODEL BF-70

CORNELL - DUBILIER ELECTRIC CORPORATION

SOUTH PLAINFIELD, N. J., U.S.A. CABLE ADDRESS: CORDU

Other plants in New Bedford and Cambridge, Mass; Providence and Hope Valley, R. I.; Indianapolis, Ind.; Sanford and Fuquay Springs, N. C.; Venice, Calif.; and subsidiaries, The Radiart Corp., Cleveland, Ohio, Tobe Deutschmann Corp., Norwood, Mass., Newport Sales and Cornell-Dubilier Electric International Corp.

GUARANTEE

This C-D DeLuxe CAPACITANCE-RESISTANCE ANALYZER is guaranteed to perform as described and to be free from any defects in materials or workmanship. Any failure due to these causes will be adjusted by repair or replacement without charge if the instrument is returned prepaid to our factory within 90 days from date of purchase.

NOTE: You are urged to read this entire booklet through carefully so that you may derive the maximum benefit from the use of this instrument. "INDEX" is on Page 18.

Form NDL-455
Printed in U.S.A.
Recorder Press, Plainfield, N. J.

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by
Cornell-Dubilier
Electric Corp.

INSULATION RESISTANCE TESTS

LEAKAGE CURRENT TABLE
DRY ELECTROLYTIC CAPACITORS

Working Voltages	DC Leakage in Ma.
25 50 100	0.01 Ma. per mfd. plus 0.5 Ma.
150 200 250 300	0.02 Ma. per mfd. plus 0.5 Ma.
350 400 450 500	0.03 Ma. per mfd. plus 0.5 Ma.

TEST FOR INSULATION RESISTANCE OF PAPER, MICA AND CERAMIC DIELECTRIC CAPACITORS

The insulation resistance of these capacitors is ordinarily independent of the DC voltage and capacity rating, consequently the BF-70 can be satisfactorily used to test high voltage capacitors used in television receivers, etc. The following test is made on all capacity and voltage ratings.

(a) Adjust Voltage Control to "OFF" position.

(b) Adjust Selector Switch to "LEAK" position.

(c) Set Meter Range Switch to 750 Volt Range. Capacity and Power Factor Controls are not in the circuit for Insulation Resistance test and so may be left in any position.

(d) Connect capacitor between Binding Post "CAP." and "COM."

(e) Advance Voltage Control to 400 volts in small steps, allowing the meter to come to rest at each step. Note, as the Voltage Control is advanced, the eye opens, then closes. This is due to the changing current which results from the increase in voltage as the Voltage Control is advanced. For capacitors above 1 mfd. allow sufficient time to permit capacitor to fully charge or an incorrect insulation resistance indication may result.

(f) Adjust Selector Switch to I.R. position and check capacitor quality.

(g) Discharge capacitor to avoid possible damage to instrument when making further tests and for eliminating possibility of shock in subsequent handling. To discharge a capacitor under test, adjust Selector Switch to "LEAK" position and adjust Voltage Control to "OFF" position. Allow sufficient time for high-capacity capacitors to discharge through the 10,000 ohm limiting resistor.

(h) Return Meter Range Switch to "OFF" position.

Open or Intermittent Capacitors

Open and intermittent capacitors are detected on the capacity test.

Shorted Capacitors

As the voltage is advanced in Step "e" no voltage will be indicated on the voltmeter. Shirt-circuited capacitors may also be identified on the capacity test.

Leaky Capacitors

If the eye flashes more than once per second after several minutes on Step "f" the capacitor is leaky. Replace capacitor.

Satisfactory Capacitors

If the visual eye remains closed after several minutes on Step "f" or flashes at a rate not exceeding once per second, the capacitor is satisfactory for normal use.

NOTES

In Step "f" the insulation resistance of the capacitor is measured by the indication of the visual eye. A rapid series of flashes indicates a low insulation resistance condition while a slow flashing rate, or no flashes, indicates satisfactory or high insulation resistance.

When testing capacities below 1 mfd. flashing will start in less than one minute after Selector Switch is adjusted in Step "f". For higher capacities flashing will take place after several minutes.

The basic flashing rate for all insulation tests will be periodic, at uniform time intervals. If the power line voltage is subject to any abrupt fluctuations the extent of eye opening for the flashes will vary. This does not interfere with the accuracy of measurement as each flash will indicate the same insulation resistance regardless of the degree of opening of the eye.

The analyzer should be kept in a warm, dry place to avoid moisture condensation on wiring, switches and terminals. It is essential to avoid any internal leakage from this source which might interfere with high insulation resistance measurements.

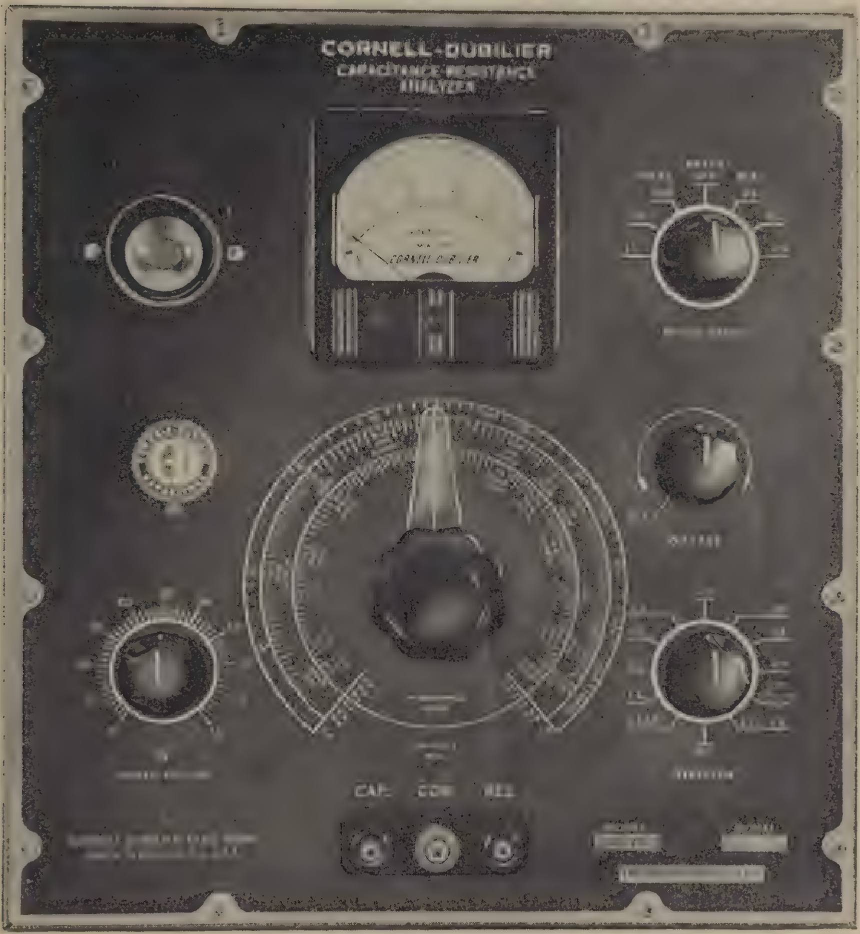
The periodic flashing rate of visual eye will indicate the condition of the insulation.

$$R = 50\,N$$

where, R is Insulation resistance in megohms
N is Number of seconds per flash

As shown above a periodic flashing rate of once per second will indicate an insulation resistance of 50 megohms.

LOCATION OF CONTROLS


CORNELL-DUBILIER
CAPACITANCE-RESISTANCE
ANALYZER
CORNELL-DUBILIER
CAP.
COM.
RES.

Control to "OFF" position. Allow sufficient time for high-capacity capacitors to discharge through the 10,000 ohm limiting resistor.

(g) Return Meter Range Switch to "OFF" position.

Direct current leakage values normally increase with idle shelf time. In order, therefore, to offset to some degree this factor it has become a standardized procedure to "age" electrolytic capacitors by applying a DC voltage equal to the rated working voltage of the capacitor for fifteen minutes prior to making any electrical tests.

When aging electrolytic capacitors the Voltage Control should be advanced gradually until rated voltage is reached as the leakage decreases. This will prevent over-voltage being applied to the capacitors.

Shorted Capacitors

Short-circuited capacitors may be identified on the capacity test and a zero voltage indicated on the leakage test Step "d" (above) as the Voltage Control is advanced.

Intermittent Shorted Capacitors

Intermittently short circuited capacitors may at first indicate as satisfactory, then become shorted for a few seconds. If the Voltmeter dips to zero and back to adjusted voltage when "aging" electrolytic capacitors, the capacitor under test is intermittently shorted.

Leaky Capacitor

See "Leakage Current Table" (Page 9).

Grounded Capacitors

When electrolytic capacitors are enclosed in metallic containers and the container *does not* constitute the negative terminal of the capacitor, it is well to test the capacitor for a grounded condition. To do this, remove the negative connection to the instrument from the capacitor and connect it to the container. If the capacitor is not grounded to the container the leakage should be zero on leakage test and the capacity near zero on the capacity test. Use rated working voltages for this test.

Leakage Current

The direct current leakage of any electrolytic capacitor is a highly variable factor and no definite boundary line can be established as to what values of leakage constitute a usable and a non-usable capacitor.

Since no hard and fast limits can be established, the following tabulation of leakage current values is given for the purpose of determining *satisfactory* leakage current characteristics.

circuits (Fig. 3), cathode by-pass, and similar applications, capacitors with a 100%-plus tolerance usually work quite satisfactorily. Likewise, a minus 10 or 20% deviation may not seriously affect the performance, However, there are more critical circuits, such as plate or grid by-pass, tuned circuits, etc., which may require the capacity to be within 10% or less of normal value.

It can be seen that the circuit requirements more or less determine the quality of the capacitor required. One capacitor may give poor operation in one type of circuit and yet operate quite satisfactorily in another. Since it is fairly difficult to set up a series of standards which would accurately meet the requirements of all types of circuits, it is suggested that a degree of good judgment be employed when using the capacitor analyzer.

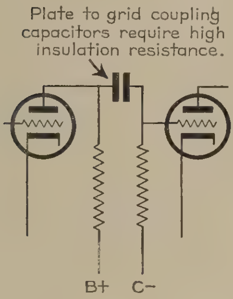


Plate to grid coupling capacitors require high insulation resistance.

Fig. 1

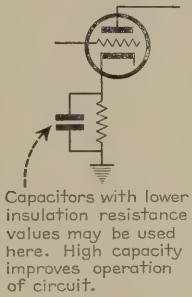

Capacitors with lower insulation resistance values may be used here. High capacity improves operation of circuit.

Fig. 2

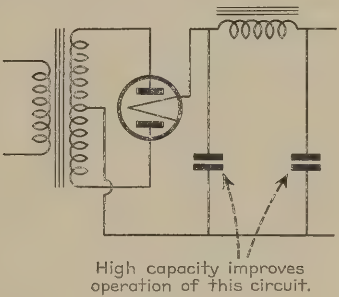

High capacity improves operation of this circuit.

Fig. 3

TESTING SEQUENCE

The Bridge is so designed that leakage and insulation resistance measurements should be made on capacitors *before* capacity test is made. This is to detect many types of capacitor defects immediately and in the case of electrolytic capacitors, permit a certain amount of "aging" to stabilize capacity and power factor characteristics.

In all capacitor testing procedures the unknown capacitor is connected between two of the binding posts. The POSITIVE terminal of the capacitor must be connected to the RED binding post marked "COM." by means of the red test lead. The NEGATIVE terminal of the capacitor is connected to the BLACK binding post marked "CAP." by means of the black test lead.

In all resistor testing procedures, the unknown resistor is connected between the center binding post "COM." and post marked "RES."

If the resistor will permit, its terminals may be connected directly to these binding posts otherwise the test leads may be used. The polarity of the test leads is not important in resistance determinations.

TEST FOR DC LEAKAGE OF ELECTROLYTIC CAPACITORS

"In-Circuit" Capacitance Measurements

Capacitors may be measured while in the circuit of the equipment by disconnecting the high potential terminal of the capacitor from the circuit. The test leads may then be connected directly to the capacitor terminals. During this test the power line and ground connections of the equipment should be disconnected.

Important: To prevent meter burnout always keep Meter Range Switch in the "OFF" position unless needed to make tests.

TEST FOR DC LEAKAGE OF ELECTROLYTIC CAPACITORS

(a) Set the Selector Switch to LEAK position and the Voltage Control to OFF position.

(b) Set the Meter Range Switch to a voltmeter range near that of the DC voltage rating of the capacitor to be tested. (For example: a capacitor rated at 350 V.D.C. set Meter Range Switch to 750 volts.) The Capacity and Power Factor Controls are not in the circuit when leakage determinations are being made. They may be left in any position.

(c) Connect the capacitor between Binding Post "CAP." and "COM." observing the proper polarity, Red being Positive and Black Negative.

(d) Advance the Voltage Control until the voltmeter reads to the DC voltage rating of the capacitor under test. Rotation of this control should be in small steps to reduce the possibility of damage to the instrument, should the capacitor under test be short circuited or excessively leaky. The meter reads the actual voltage applied to the capacitor under test.
Voltage reading will tend to increase after a short time as the leakage current reaches a stable value. The Voltage Control should be retarded to the rated voltage of the capacitor under test. A stable value should be reached before the leakage current measurement is made for greater accuracy.

(e) Adjust Meter Range Switch to the 75 Ma. position and read the 75 scale of the meter. If the reading is less than 15 milliamperes adjust the Meter Range Switch to the 15 Ma. position; if the reading is less than 1.5 Ma. adjust Meter Range Switch to 1.5 Ma. position. The selection of the proper scale range will provide most accurate current readings.
For permissible values of leakage current see "Leakage Current Table," Page 9.

(f) Discharge capacitor to avoid possible damage to instrument when making further tests and for eliminating possibility of shock in subsequent handling. To discharge a capacitor under test, adjust Voltage

Cornell - Dubilier
DeLuxe
CAPACITANCE - RESISTANCE ANALYZER
Model BF-70

GENERAL

The Model BF-70 Capacitance-Resistance Analyzer quickly and accurately measures the important characteristics of substantially all types of capacitors and resistors. It detects capacitor defects such as Opens and Shorts, Intermittents, High and Low Capacities and High Leakage and Power Factor of Electrolytic Capacitors, as well as low Insulation Resistance of Paper, Mica, and Ceramic Dielectric Capacitors.

As in a capacitor, there is also capacity between wires and shielding, windings of transformers, wires in cables, etc. Such capacity measurements can be made by following the instructions outlined for "Capacitance Tests" (Page 11). Insulation resistance may be measured between coil windings, etc. For such measurements, simply adjust the controls as described under "Insulation Resistance Test" (Page 9). The instrument may also be found useful for determining Circuit Continuity.

Although the analyzer is not easily damaged unless abused, the instructions for its operation should be followed carefully. On leakage tests, a shorted capacitor should be removed from the test terminals after a few seconds. If allowed to remain connected over a longer period of time it may cause excessive wear on the tubes and component parts.

SPECIFICATIONS

Power Supply: 110-125 volts AC, 50-60 cycles

Capacitance measurement in four ranges: .00001 MFD. to 2000 MFD.

Resistance measurement in three ranges: 2.5 OHMS to 25 MEGOHMS

Power Factor: 0 to 50% at 60 cycles

The Power Factor of all electrolytics is indicated directly on a scale.

Leakage Current

A self-contained 600 volt continuously adjustable DC power supply permits measurements of electrolytic capacitor leakage current at exact rated voltage.

Insulation Resistance

Insulation resistance measurements of paper, mica and ceramic dielectric capacitors are quickly made by means of the visual eye, indicating the degree of quality of the capacitor under test.

Meter

A DC Volt-Milliammeter (Voltmeter resistance 1,000 ohms per volt) is provided to measure the voltage applied to capacitors for leakage measurement. Measurement of leakage current of electrolytic capacitors is made direct in milliamperes. External voltage may be measured up to 750 V.D.C. in three ranges and current up to 75 milliamperes in three ranges.

Circuit

Capacitance, Resistance and Power Factor Measurements are made on a line frequency Wien Bridge Circuit. The balance or null condition is indicated by a maximum opening of the "eye" (6E5) tube. Measurements are independent of line voltage variations and can be made with far greater accuracy than by any other method not employing a bridge circuit.

Tubes

1 — 6W4GT Rectifier
1 — 6E5 Bridge Detector and Insulation Resistance Indicator
1 — 6C5 Amplifier

Case

Portable metal case with hammered gray enamel finish. Carrying handle is recessed so the instruments may be conveniently stacked.

Case size: $5\frac{1}{2}''$ deep x 11″ high x 10″ wide.
Weight: 10 lbs., 3 oz.

DEFECTIVE CAPACITORS AND CAPACITANCE TOLERANCE

While it is evident that open, shorted or intermittent capacitors are definitely defective, it is somewhat difficult to set up exact standards for leaky or high and low capacity capacitors. In the case of grid coupling capacitors (Fig. 1), a very high insulation resistance is required. This is because a low insulation resistance capacitor will pass direct current, which in this circuit, will decrease the grid bias on the tube to which it is connected. For such capacitors, the flashing rate as indicated by the analyzer leakage test should be not more than once every two seconds.

Capacitors in low voltage applications (Fig. 2), such as cathode bypass, where 10 or 25 volts is the maximum condition, a leakage indication of two flashes or less per second may be satisfactory. Wherever a capacitor is shunted by a resistance, greater leakage or lower insulation resistance can usually be tolerated.

One of the most important measurements of capacitor quality is the insulation resistance test. A low resistance capacitor means that the quality of this unit has been impaired and if subjected to normal rated voltage will not give very satisfactory useful life.

High and low capacity, that is a deviation of more than 20% from the normal capacity rating, can be tolerated in most circuits. For filter

PARTS LIST

MAINTENANCE PARTS LIST

Model BF-70 Capacitance-Resistance Analyzer

CIRCUIT SYMBOL	COMPONENT	VALUE	RATING	C-D PART No.
C1	Capacitor	.0002 Mfd.	+4—0%	5R-5T2
C2	Capacitor	.02 Mfd.	±2%	ST-6S1
C3	Capacitor	2.0 Mfd.	±2%	HC-3296
C4	Capacitor	.01 Mfd.	600 V.D.C.	CUB-4S1
C5, C6, C7	Capacitor	8.0 Mfd.	500 V.D.C.	BR-850
C8, C9	Capacitor	.02 Mfd.	600 V.D.C.	CUB-6S2
C10	Capacitor	.01 Mfd.	400 V.D.C.	CUB-4S1
C11	Capacitor	.25 Mfd.	400 V.D.C.	CUB-4P25
R1	Resistor	50 Ohm	1W. 1%	34866
R2	Resistor	5,000 Ohm	1W. 1%	34867
R3	Resistor	500,000 Ohm	1W. 1%	34868
R4	Resistor	20 Megohm	½W. 5%	21591
R5	Resistor	80,000 Ohm	1W. 1%	34869
R6	Potentiometer	4,000 Ohm	5%	20886
R7	Resistor	5,100 Ohm	½W. 10%	34684
R8	Potentiometer	750 Ohm	5%	34879
R9	Resistor	47,000 Ohm	2W. 10%	34670
R10	Resistor	100,000 Ohm	1W. 10%	34874
R11	Potentiometer	50,000 Ohm	15W.	34859
R12	Resistor	1 Megohm	½W. 10%	21590
R13	Resistor	10 Megohm	½W. 10%	21593
R14	Resistor	15,000 Ohm	1W. 1%	34863
R15	Resistor	150,000 Ohm	1W. 1%	34864
R16	Resistor	750,000 Ohm	1W. 1%	34865
R17	Resistor	2.0 Ohm	1W. 1%	34860
R18	Resistor	8.7 Ohm	1W. 1%	34861
R19	Resistor	289.3 Ohm	1W. 1%	34862
R20	Resistor	500 Ohm	10W. 20%	34889
R21	Resistor	10,000 Ohm	10W. 20%	34871
R22	Resistor	2 Megohm	½W. 10%	21584
R23	Resistor	10,000 Ohm	½W. 10%	21595
R24	Resistor	10 Megohm	½W. 10%	21593
SW-1	Selector Switch			34856
SW-2	Meter Range Switch			34854
T	Transformer			34655
N	Neon			21172
M	Meter	1 Milliampere		

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READING THE METER SCALE

The Volts and Ma. markings on the Meter Range Switch refer to full meter scale reading. The scale is marked 0-15 and 0-75 for voltage and milliampere reading.

Meter Range Switch Position	Read Meter Scale
750 V.	0-75 and add one zero
150 V.	0-15 and add one zero
15 V.	0-15 directly
75 Ma.	0-75 directly
15 Ma.	0-15 directly
1.5 Ma.	0-15 and move the decimal one place to left.

For example on the 1.5 Ma. position a reading of 9 would represent .9 Ma. on the 0-15 scale.

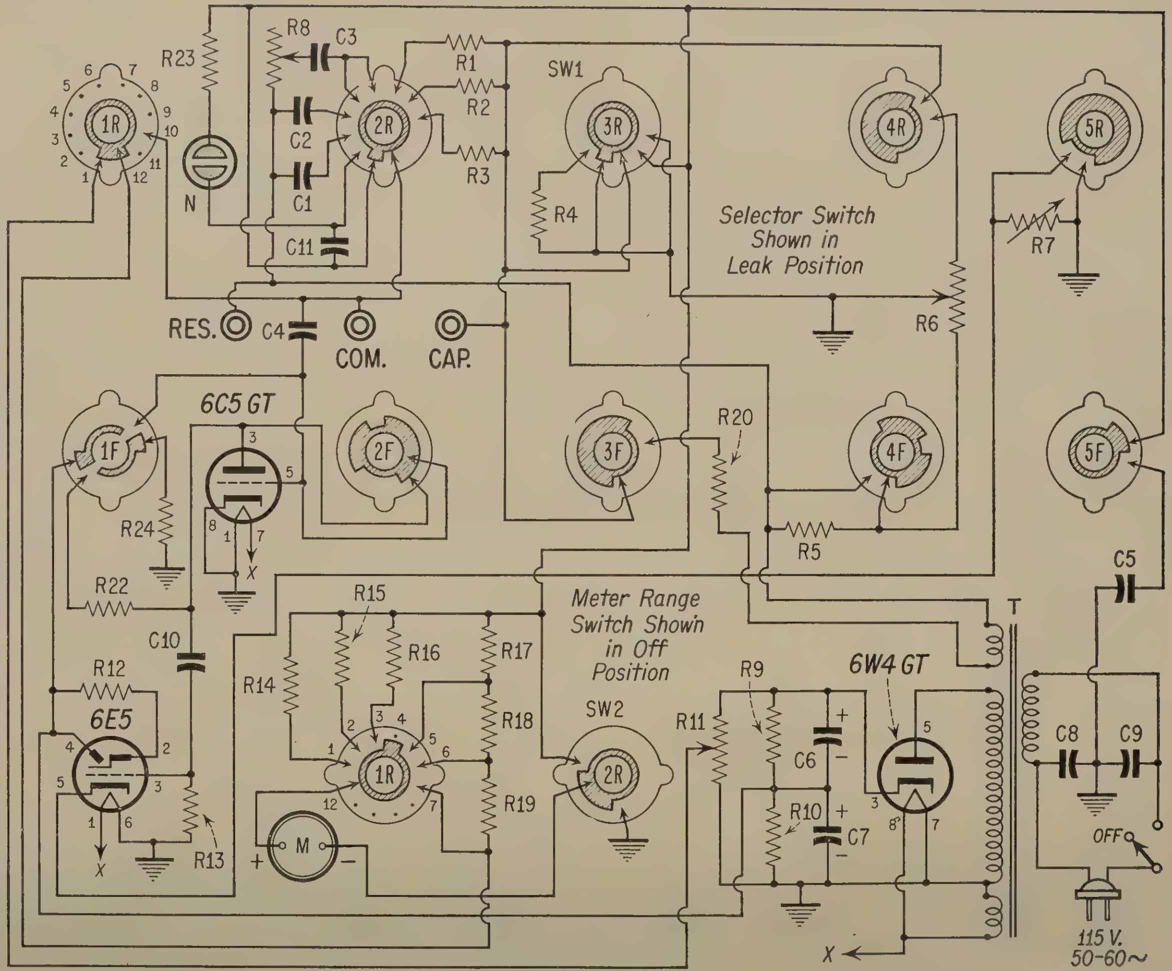
MAINTENANCE

If the 6E5 tube is replaced it may be necessary to readjust the miniature rheostat R7 located on the chassis. This rheostat effects the degree of shadow angle when a capacitor is measured for Insulation Resistance. Adjustment may be made as follows:

1. Remove unit from case.
2. Allow unit to warm up a few minutes.
3. Adjust Selector Switch to Leak position, the Meter Range Switch and Voltage Control to OFF position and nothing connected to Binding Post. The Master and Power Factor Controls are not in the circuit and may be left in any position.
4. Adjust R7 rheostat until the eye is closed or zero angle is indicated. NOTE: Care should be exercised in not increasing the resistance of R7 more than is necessary.

SELECTOR SWITCH POSITIONS	
1	Leak
2	1R
3	C1
4	C2
5	C3
6	C4
7	R1
8	R2
9	R3
10	Ext. V.
11	Ext. Ma.

METER RANGE SWITCH POSITIONS	
1	15 Volts
2	150 Volts
3	750 Volts
4	Off
5	75 Ma.
6	15 Ma.
7	1.5 Ma.



Selector Switch Shown in Leak Position
Meter Range Switch Shown in Off Position
SW1
SW2
1R
2R
3R
4R
5R
1F
2F
3F
4F
5F
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R22
R23
R24
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
N
RES.
COM.
CAP.
6C5 GT
6E5
6W4 GT
M
T
X
OFF
115 V. 50-60~

Circuit Diagram — Model BF-70

(f) This procedure is recommended in all cases when measuring very low values of capacitance.

SPECIAL TYPES OF ELECTROLYTIC CAPACITORS

Non-Polarized Capacitors

Where direct current types of electrolytic capacitors are of the non-polarized type, the same test procedure is followed as has been outlined as far as capacity is determined. However, leakage current is checked in both directions. This is done by checking the leakage with the instrument terminals connected to the capacitor in one direction and then again checking the leakage with the terminals reversed to the other direction.

Alternating Current Type Capacitors

Most alternating current types of electrolytic capacitors are used with capacitor type, single phase, alternating current motors of fractional horsepower sizes.

In connection with such motor applications, there is always an optimum value of capacity which is required for the maximum starting torque of the motor. Any variation below or above this value will cause a proportionate reduction in the starting torque of the motor. Just how much variation from the rated value of a capacitor can be tolerated depends a great deal upon the starting torque requirements of a given motor application.

As a general rule, a capacitor should be replaced if the measured capacity is found to be more than 25% below the rated capacity.

No direct current leakage test is required or desirable on the alternating current types of electrolytic capacitors. Capacity and power factor determinations when made on a bridge type instrument are only approximations. True measurements can be made only by the Voltmeter-Ammeter-Wattmeter method.

Power Factor

A high power factor causes a small reduction in starting torque of the motor but this is not of serious consequence as a rule. The nominal power factor of the AC type electrolytic capacitor lies within the range of from 5% to 10%. Values of power factor as great as 30% should not be the cause of the capacitor's rejection unless low values of capacity are also encountered at the same time and the particular motor involved has insufficient starting torque.

RESISTANCE MEASUREMENTS

The Model BF-70 will quickly and effectively measure the DC resistance of wire-wound or carbon, fixed or variable resistors, volume controls, pads and other resistive-type attenuators.

RESISTANCE MEASUREMENTS

Three ranges are provided for line frequency bridge measurements.

(a) Adjust Meter Range Switch and Voltage Control to "OFF" position and adjust Selector Switch to position R1, R2 or R3.

Resistance	Selector Position	Read on Scale
2.5 ohms to 2,500 ohms	R1	R1
250 ohms to 250,000 ohms	R2	R2
25,000 ohms to 25 megohms	R3	R3

(b) Connect resistor being measured between the two Binding Posts "COM." and "RES."

(c) Rotate the Master Control slowly until null ("eye" open) position is obtained. Read resistance directly from the scale.

(d) If the resistance reading is obtained near the high end (right hand side) of the scale, the best accuracy will be obtained if the next higher resistance range is used. Example: A 1000 ohm resistor should be measured on scale range R2 instead of R1.

Open Resistor

If a null indication ("eye" open) appears on all three resistance scale ranges at the extreme clockwise position the resistor under test is Open.

Short Circuited Resistor

If a null indication ("eye" open) appears on all three resistance scale ranges at the extreme counter-clockwise position the resistor under test is Shorted.

OPERATING THE DC VOLT-MILLIAMMETER

The BF-70 provides a DC Volt-Milliammeter (Voltmeter resistance 1,000 ohms per volt) for *external* DC voltage and milliampere measurements.

(a) Adjust Voltage Control and Meter Range Switches to "OFF" position. The Master Control and Power Factor Control are not in the circuit and may be left in any position.

(b) Adjust Selector Switch to "EXT. VOLTS" position or "EXT. MA." position.

(c) Adjust the Meter Range Switch to a range greater than the voltage or current to be measured, if known. If unknown, adjust Meter Range Switch to the highest range.

(d) Insert test leads to the Binding Post "CAP." negative and "COM." positive.

CAPACITANCE AND POWER FACTOR TESTS

The capacitance and power factor tests may be made simultaneously. The Power Factor Control is operative only when range C3 and C4 are in use.

(a) Adjust Meter Range Switch and Voltage Control to "OFF" position; adjust Power Factor Control to zero position and Selector Switch to position C1, C2, C3 or C4, depending upon the capacitance of the unknown unit under test.

Capacitance	Selector Position	Read on Scale
.00001 mfd. to .005 mfd.	C1	C1
.001 mfd. to .5 mfd.	C2	C2
.1 mfd. to 50 mfd.	C3	C3
45 mfd. to 2000 mfd.	C4	C4

(b) Connect unknown capacitor between Binding Post "CAP." and "COM."

(c) Rotate the Capacity Control slowly until the "eye" is open to maximum and then read capacitance directly from the scale in use.

When operating scale range C3 or C4, alternately adjust the Capacity Control and then the Power Factor Control until maximum opening of the "eye" is observed. At this point the correct capacitance and power factor can be read directly from the two scales.

(d) If the capacity reading is obtained near the higher end (right hand side) of the scale the best accuracy will be obtained if the next higher capacity range is used. Example: A .005 mfd. capacitor should be measured on scale range C2 instead of C1.

Open Capacitor

If a null indication ("eye" open) appears on C1, C2, and C3 scale range at extreme counter-clockwise position, the capacitor is Open. A flickering or unstable "eye" indicates an Intermittent Open.

Short Circuited Capacitor

If a null indication ("eye" open) appears on C1, C2, C3 and C4 scale ranges at extreme clockwise position the capacitor is short circuited. Short circuited capacitors may also be detected on the DC leakage test and insulation tests.

Intermittent Capacitor

When the null position ("eye" open) is reached and the "eye" flickers or is unstable, an intermittent Open or Short in the capacitor is indicated. An intermittent may be internal, due to an electrical defect, or external due to loose or poor contact terminals to the internal section of the capacitor or defective leads between the capacitor and instrument.

CAPACITANCE AND POWER FACTOR TESTS

Capacitor Tolerances

See Defective Capacitors and Capacitance Tolerance, Page 4.

Power Factor (For Electrolytics)

The power factor of a dry electrolytic capacitor may have little bearing on its efficient functioning in a circuit. Normal values of power factor range from 5 to 15 percent for single section units rated at any voltage from 5 to 500 volts.

Where multiple section electrolytic capacitors contain sections rated at both high and low voltages, for example: 25 and 450 working volts, the power factor of the lower voltage section may nominally be as high as 50%.

The effect of a high value of power factor in either a filter or by-pass function may readily be offset by a value of capacity in excess of the rated value of a particular capacitor. It is recommended that higher values of power factor be a cause of rejection of capacitors only when such high values are accompanied by low capacity and evidence of failure of proper circuit operation. A high value of power factor should not in itself be a sufficient cause for the rejection of a capacitor.

Measuring Very Low Values of Capacitance

In measuring very low values of capacitance the "inherent capacitance" of the instrument itself must be taken into account.

To measure the "inherent capacitance" of your instrument, proceed as follows (with nothing connected to the Binding Posts):

(a) Set Range Switch to range C1.

(b) Rotate the Master Control until a null (open eye) indication is obtained.

(c) The "inherent capacitance" can then be read directly from the C1 scale. Make a note of the reading.

(d) Now measure the capacitance of the unknown capacitor under test. (See Capacitance and Power Factor Test, Page 11.)
Make a note of this reading.
Greatest accuracy can be obtained by connecting the unknown capacitor directly to the binding posts by means of the capacitor terminals, eliminating the use of the test leads. This procedure will eliminate any capacity normally introduced by the long test leads.

(e) The "inherent capacitance" obtained in "c" above should then be deducted from the capacitance reading in "d" above of the capacitor under test. The resulting capacitance will then be the true capacitance of the unit under test.

Example:

If an unknown capacitor reads .00003 mfd. and the "inherent capacitance" of your instrument is .00001 mfd., then the real capacitance of the unknown unit will be .00002 (.00003 – .00001).

FLYBACK TRANSFORMER & YOKE CHECKER

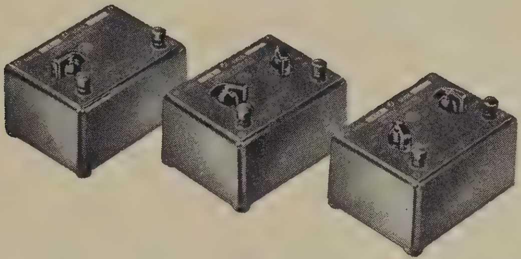
MODEL BF-80

The Cornell-Dubilier Flyback Transformer and Yoke Checker provides the television serviceman with a rapid and convenient means of locating defects in flyback transformers and yokes. This instrument is extremely sensitive and will immediately detect a single short circuited turn in the windings of either a flyback transformer or yoke. Without the use of such an instrument as the Cornell-Dubilier Flyback Transformer and Yoke Checker, it is most difficult to detect such a defect. Resistance measurements are not effective because a short circuited turn causes only a minute change in resistance and usually the resistance of a good transformer or yoke is unknown and subject to a wide tolerance. A short circuited turn on the other hand, causes a major change in inductance, which this instrument quickly detects.

In addition to detecting short circuited turns in magnetic windings, this instrument is designed to also provide a means for quickly detecting OPEN CIRCUITED conditions in transformers, yokes, coil and switches, or short circuited elements in vacuum tubes.

MODEL BF-80 CHECKER
NET PRICE complete with tube **$46.45**

CAPACITOR DECADES



CORNELL-DUBILIER CAPACITOR DECADES provide a reliable and accurate source of measured capacitances for substitution purposes in a wide variety of electronic applications within the voltage and capacitance ratings of each unit.

Units of capacitance can be selected from the direct reading switch scale markings and the precise value may be read directly from the hand calibrated chart provided with each instrument.

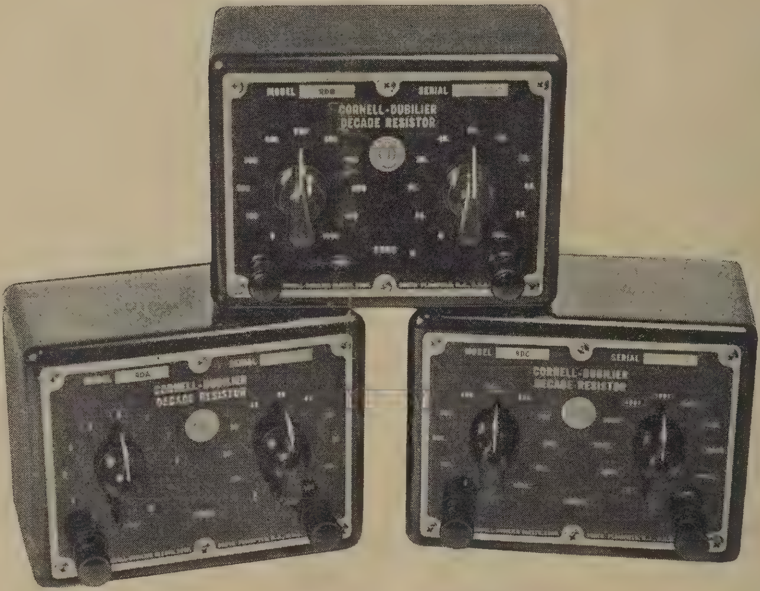
CORNELL-DUBILIER CAPACITOR DECADES may be grouped in parallel to provide a wide range of accurate standards with maximum flexibility. For example, one each of decades CDA, CDB and CDC in parallel will permit a selection of capacitances from 0 to 11.111 mfds., in steps of .0001 mfd.

Five C-D Decade models are available with ratings and tolerances as shown below:

Rated Voltage - 600 D.C. - 220 A.C.

Model	Capacity	+ or − Tol.	Dielectric	Net Price
CDA-5	.011 mfd. in .0001 mfd. steps	5%	Mica	$11.35
CDB-5	1.1 mfd. in .01 mfd. steps	5%	Oil-Paper	11.35
CDB-3	1.1 mfd. in .01 mfd. steps	3%	Oil-Paper	13.50
CDC-5	10.0 mfd. in 1.0 mfd. steps	5%	Oil-Paper	19.95
CDC-3	10.0 mfd. in 1.0 mfd. steps	3%	Oil-Paper	22.00

Cornell-Dubilier
DECADE RESISTORS


MODEL RDB SERIAL
CORNELL-DUBILIER DECADE RESISTOR
MODEL RDA SERIAL
CORNELL-DUBILIER DECADE RESISTOR
MODEL RDC SERIAL
CORNELL-DUBILIER DECADE RESISTOR

MODELS RDA-RDB-RDC

1 OHM TO 1,111,110 OHMS
IN STEPS OF 1 OHM

C-D Decade Resistors provide a reliable source of resistance for substitution purposes in a wide variety of electronic and electrical applications within the current and resistance rating of each unit. Units of resistance are selected from the direct reading panel switch scale.

Each instrument permits a possible selection of 110 resistance values.

RDA	RDB	RDC
$12.15	$12.50	$12.50

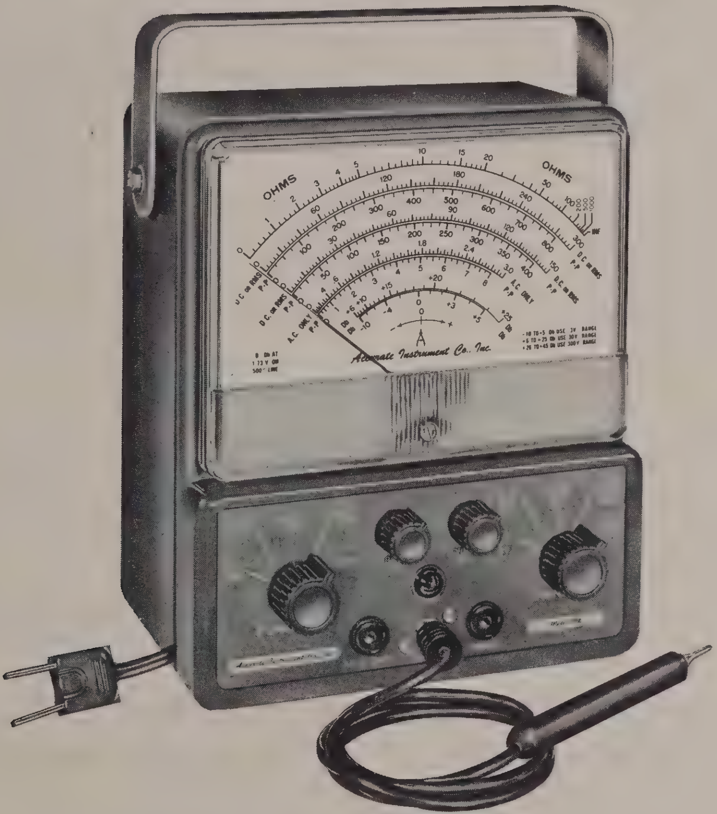
USER'S NET PRICES

OPERATING INSTRUCTIONS

FOR THE

MODEL 152

SENIOR V.T.V.M.


OHMS
OHMS
D.C. OR RMS
P-P
A.C. ONLY
DB
INF
Accurate Instrument Co., Inc.

Manufactured and Guaranteed By:

ACCURATE INSTRUMENT CO., INC.

911 FAILE STREET • NEW YORK 59, N. Y.

PRINTED IN U.S.A.

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The model 152 vacuum tube voltmeter has been designed for the service of Radio, Television, Hi-Fi amplifiers and other devices.

The Model 152 VTVM provides the following services.

D.C. Volts (at 11 megohms input resistance):
0 to 3/30/150/300/1500 volts.

A.C. Volts (RMS):
0 to 3/30/150/300/1500 volts.

Resistance:
0 to 1000/10,000/100,000 ohms.
0 to 10/1,000 megohms with center scale values of 10, 100, 1,000, 100,000 ohms and 10 megohms.

Zero Center D. C. Voltmeter (for discriminator alignment):
0 to 1.5/15/75/150/750 volts (at 11 megohms input resistance).

Peak to Peak Voltmeter:
0 to 8/80/400/800 volts.

Decibels:
−10 to +5 db.
+6 to +25 db.
+26 to +45 db.
All based on 0 db. at 1.73 v on 500 ohm line.

D.C. VOLTS

The Model 152 provides 5 D.C. Voltage ranges at 11 megohms input resistance — 0 to 3/30/150/300/1500 volts.

To Use the Model 152 D.C. Voltage ranges:

1. Insert the line cord into a 110-120 volt 60 cycle power source.
2. Rotate the "Function" switch to either the "D C V neg." or "D C V pos." position and allow 1 minute for the tubes to warm up.
3. Adjust the meter to read zero volts by rotating the "balance adjust" control.
4. Insert the black regular test lead into the jack marked "common."
5. Insert the D.C. probe plug into the jack marked "D.C. volts."
6. Rotate the "range" switch to the range desired.
7. Place the test leads across the D.C. voltage to be measured. (If the meter reads backwards, rotate the function switch to the other D.C.V. position.)
8. Read the voltage from the appropriate black meter scales.

For the 3 volt range:

Use the 300 scale and divide by 100.
Each major division is .2 volts.
Each minor division is .04 volts.

For the 30 volt range:

Use the 300 scale and divide by 10.
Each major division is 2 volts.
Each minor division is .4 volts.

For the 150 volt range:

Use the 150 volt scale directly.
Each major division is 10 volts.
Each minor division is 2 volts.

For the 300 volt range:

Use the 300 volt scale directly.
Each major division is 20 volts.
Each minor division is 4 volts.

For the 1500 volt range:

Use the 150 volt scale and multiply by 10.
Each major division is 100 volts.
Each minor division is 20 volts.

TO MEASURE A.C. VOLTS

The Model 152 provides 5 A.C. voltage ranges calibrated in R.M.S. of a sine wave.

0 to 3/30/150/300/1500 volts.

To Use the Model 152 A. C. Voltage Ranges:

1. Insert the line cord into any 110-120 volt 60 cycle power source.
2. Rotate the "function" swich to the "A.C. volts" position — allow 1 minute for the tubes to warm up.
3. Adjust the meter to read zero volts by rotating the "balance" adjust control.
4. Insert the black regular test lead into the jack marked "common."
5. Insert the regular red test lead into the jack marked "ACV-ohms."
6. Rotate the "range" switch to the range desired.
7. Place the test leads across the A.C. voltage to be measured.
8. Read the voltage from the appropriate black meter scale.

For the 3 volt range:

Use the special 3 volt A.C. scale directly.
Each large division is .1 volts.
Each small division is .05 volts.

For the 30 volt range:

Use the 300 scale and divide by 10.
Each major division is 2 volts.
Each minor division is .4 volts.

For the 150 volt range:

Use the 150 scale directly.
Each major division is 10 volts.
Each minor division is 2 volts.

For the 300 volt range:

Use the 300 volt scale directly.
Each major division is 20 volts.
Each minor division is 4 volts.

For the 1500 volt range:

Use the 150 scale and multiply by 10.
Each major division is 100 volts.
Each minor division is 20 volts.

RESISTANCE MEASUREMENTS

The Model 152 provides 5 resistance ranges.
0 to 1,000/10,000/100,000 ohms.
0 to 10/1,000 megohms.

To Use the Resistance Ranges:

1. Insert the line cord into a 110-120 volt 60 cycle power source.
2. Rotate the "function" switch to the "ohms" position and allow 1 minute for the tubes to warm up.
3. Adjust the meter to read "inf." (full scale) by means of the "ohms" adjust control.
4. Insert the regular test leads into the jacks marked "A.C. Volts-Ohms" and "common."
5. Short the test leads (touch their tips together.) The meter reading should drop to zero resistance.
6. Re-adjust the meter to read zero resistance (same as zero volts) by means of the "balance adjust" control.
7. Open the shorted test leads and repeat the steps 3 to 6. With the test leads open, the meter should read infinite ohms (full scale.) With the test leads shorted, the meter should read zero resistance (same as zero volts.)
8. Rotate the "range" switch to the range desired.
9. Place the test leads across the resistance to be measured.
10. Read the scale and multiply by the scale multiplying factor of the range switch.

Use the RX1 position for 0-1000 ohms (10 ohm center scale).
(Read meter scale directly)
Use the RX10 position for 0-10,000 ohms (100 ohms center scale).
(Multiply meter scale by 10)
Use the RX100 position for 0-100,000 ohms (1000 ohms center scale).
(Multiply meter scale by 100)
Use the RX10K position for 0-10 megohm (100,000 ohms center scale).
(Multiply meter scale by 10,000)
Use the RX1M position for 0-1000 megohm (10 megohms center scale).
(Multiply meter scale by 1,000,000)

Note: Although **any** range may be used for adjusting the resistance ranges (steps 3 to 6) it is advisable to use an intermediate range rather than the lowest or highest ranges. Continued use of the lowest resistance range with the leads shorted may exhaust the internal 1½ volt cell. Leakage resistance may cause the highest range to act unstable. We therefore suggest any intermediate range. An adjustment on any range will hold for all.

ZERO CENTER D.C. VOLTMETER

The Model 152 provides 5 zero center D. C. ranges.

0 to 1.5/15/75/150/750 volts at 11 megohms input resistance useful for discriminator alignment and general purpose zero center readings.

To Use the Zero Center Voltmeter:

1. Insert the line cord into a 110-120 volt 60 cycle power source.
2. Rotate the "function" switch to the "D.C.V.-pos." position and allow 1 minute for the tubes to warm up.
3. Adjust the meter to read center scale by means of the "balance adjust" knob. The small zero center scale directly above the Accurate insignia is provided to assist in setting the meter.
4. Insert the black regular test lead into the jack marked "common."
5. Insert the D.C. probe plug into the jack marked "D.C. volts."
6. Rotate the "range" switch to the desired range. **Note:** Since the instrument is now a center zero meter, all ranges are ½ that marked on the range switch.
7. Place the test leads across the voltage to be measured. Positive voltages will cause the meter to read upscale. Negative voltages will cause the meter to read downscale.

It is usually unecessary to know an exact voltage reading when using a zero-center meter. If it is desirous to know the exact voltage being measured, read the voltage scale corresponding to the position of the range switch and **subtract** ½ the range switch position.

Example: If the meter reads 120 when using the 300 volt position of the range switch (which corresponds to the 150 volt zero center scale) then

120 (meter reading)
—150 (½ the range switch setting)
— 30 volts

PEAK TO PEAK VOLTMETER

The Model 152 provides 4 peak to peak voltage ranges which are applicable to the special wave shapes encountered in Radio, Television and pulse work. The ranges are:

0 to 8/80/400/800 volts peak to peak.

To Use the Peak to Peak Voltmeter:

1. Insert the line cord into a 110-120 volt 60 cycle power source.
2. Rotate the "function" switch to the "A.C.V.-P-PV" position and permit the instrument to warm up.
3. Adjust the meter to read zero volts by rotating the "balance adjust" control.
4. Insert the black regular test lead into the jack marked "common," and the red regular test lead into the jack marked "A.C.V.-ohms."
5. Rotate the range switch to the range desired.
6. Connect the test leads across the circuit whose voltage is to be measured.
7. Read the voltage from the appropriate **Red** meter scale.

For the 8 volt peak to peak range:

Read the red 8 volt scale directly.
Each major division is .5 volts.
Each minor division is .25 volts.

For the 80 volt peak to peak range:

Read the red 800 scale and divide by 10.
Each major division is 5 volts.
Each minor division is 2.5 volts.

For the 400 volt peak to peak range:

Read the red 400 volt scale directly.
Each major division is 25 volts.
Each minor division is 12.5 volts.

For the 800 volt peak to peak range:

Read the red 800 volt scale directly.
Each major division is 50 volts.
Each minor division is 25 volts.

DECIBELS

The Model 152 povides 3 decibel ranges all based on 0 db. (6 mw) at 1.73 volts on 500 ohm line.

−10 to + 5 db.
+ 6 to +25 db.
+26 to +45 db.

To Use the Model 152 Decibel Ranges:

1. Insert the line cord into a 110-120 volt 60 cycle power source.
2. Rotate the "function" switch to the "A.C. volts" position and allow 1 minute for the tubes to heat up.
3. Adjust the meter to read zero volts by means of the "balance" adjust control.
4. Insert the black regular test lead into the jack marked "common."
5. Insert the regular red test lead into the jack marked "A.C.V.-ohms."
6. Rotate the "range" switch to the range desired.
   Use the 3 volt position for the −10 to +5 db. range.
   Use the 30 volt position for the +6 to +25 db. range.
   Use the 300 volt position for the +26 to +45 db. range.
7. Place the test leads across the voltage to be measured.
8. Read decibels from the regular decibel scale or read the voltage as volts and convert to decibels by means of the chart which appears on the next page.
   When using the −10 to +5 db. range, read the scale directly.
   When using the +6 to +25 db. range, read the scale directly.
   When using the +26 to +45 db. range, use the +6 to +25 db. and add +20.

DB CHART

NOTE: The chart holds true only for 500 ohm lines. For any other line, the voltage can be calculated as follows:

$$P = \frac{E^2}{R}$$

P = Power in Watts
E = Voltage
R = Resistance

The table may be extended in any direction by the following formulae:

$$\text{D.B.} \ +10 = P \times 10$$
$$\text{D.B.} \ -10 = \frac{P}{10} = \frac{E}{\sqrt{10}} = -E \times \sqrt{10}$$

or

Where P = Watts
E = Volts
$\sqrt{10} = 3.16$

TECHNICAL DB DATA

POWER LEVEL DB	POWER 6 MW AT 0 DB WATTS	VOLTS BASED ON 6 MW AT 0 DB IN 500 OHMS	POWER LEVEL DB	POWER 6 MW AT 0 DB WATTS	VOLTS BASED ON 6 MW AT 0 DB IN 500 OHMS
–10	0.00060	0.5477	20	0.60000	17.3205
– 9	0.00075	0.6145	21	0.75535	19.434
– 8	0.00095	0.6895	22	0.95093	21.805
– 7	0.00119	0.7737	23	1.19716	24.466
– 6	0.00150	0.8681	24	1.50713	27.451
– 5	0.00189	0.9740	25	1.89747	30.801
– 4	0.00238	1.0928	26	2.38865	34.559
– 3	0.00300	1.2262	27	3.0071	38.776
– 2	0.00378	1.3758	28	3.7857	43.507
– 1	0.00476	1.5437	29	4.7660	48.816
0	0.00600	1.7321	30	6.000	54.772
1	0.00755	1.9434	31	7.5535	61.455
2	0.00950	2.1805	32	9.5093	68.954
3	0.01197	2.4466	33	11.9716	77.368
4	0.01507	2.7451	34	15.0713	86.808
5	0.01987	3.0801	35	18.9747	97.400
6	0.02388	3.4559	36	23.8865	109.285
7	0.0300	3.8776	37	30.071	122.620
8	0.0378	4.3507	38	37.857	137.582
9	0.0476	4.8816	39	47.660	154.369
10	0.0600	5.4772	40	60.000	173.205
11	0.0755	6.1455	41	75.535	194.34
12	0.0950	6.8954	42	95.093	218.05
13	0.1197	7.7368	43	119.716	244.66
14	0.1507	8.6808	44	150.713	274.51
15	0.1897	9.7400	45	189.747	308.01
16	0.2388	10.9285	46	238.865	345.59
17	0.300	12.2620	47	300.71	387.76
18	0.37857	13.7582	48	378.57	435.07
19	0.47660	15.4369	49	476.60	488.16
			50	600.00	547.72

SERVICE AND MAINTENANCE NOTES

The Model 152 is a rugged instrument designed for years of trouble free service.

Should trouble develop in your instrument, it is advisable to write to our service department for the necessary steps to clear up the difficulty. Many of the troubles that do develop are caused by misuse. Care should always be exercised in connecting the instrument so that burn-outs and overloading are avoided.

To remove the instrument from its case, remove the six screws located in back of the instrument.

Inability to balance the meter may be caused by a defective amplifier tube. Replace with a new 6211 or 5814. These are "industrial" and "ruggedized" low gas versions of the 12AU7 which may be used in an emergency. We do not recommend continued use of the 12AU7 as most tubes contain too much gas for instrument work.

Inability to test A.C. is usually caused by a burnt out 9006 rectifier. Replace with a new tube.

Inability to reach full scale on resistance ranges may be caused by a defective 1.5 volt cell. Inaccurate low resistance readings can also be caused by a defective 1.5 volt cell.

CAUTION — Do not use lacquer thinners, acetone, carbon-tet or other organic solvents to clean the meter or case — Use a mild detergent and water.

CALIBRATION

It is not suggested that calibration be attempted unless suitable standardizing equipment having an accuracy of .5% is available. Do not standardize against other manufacturers 20,000 ohm per volt, 1,000 ohm per volt or V. T. V. M. In no case should calibration be attempted unless the instrument has been warmed up for at least 15 minutes.

The calibration controls are located at the top of the printed board.

The **D.C. Calibrator** located at the right is adjusted on the 30 volt range at 24 volts.

The **A.C. Calibrator** located in the center is adjusted on the 150 volt range at 120 volts.

The **Diode Control** located at the left is adjusted on the **3 volt** range **before** A.C. calibration. It is adjusted so that the meter does not shift when switched between the 3 and 30 volt ranges. No test leads should be connected when adjusting this control. The purpose of this control is to balance out the contact potential present in all diodes.

Note: The 6211 tube used in this instrument has been selected for low gas and contact potential. Use of a 12AU7 may cause a meter zero shift whenever ranges are changed.

REPLACEMENT PARTS

Complete Meter	$9.00
Meter front only	1.00
Transformer	2.00
Rectifier	1.00
6211 Tube	1.50
9006 Tube (each)	.85
Precision Resistors (give value)	.25
Balance Control (5000 ohms)	.75
Ohms adjust control (1000 ohms)	.75
Function Switch	1.50
Range Switch	1.50
Electrolytic Capacitor	.75
.01 mfd. 2000 volt capacitor	.50
Other capacitors (give value)	.35
Instrument case (rear section)	1.75
Knobs (specify type)	.20
Tip jacks (black or red)	.15
Neon lamp	.25
D. C. Probe (complete)	1.50

IMPORTANT

The Model 152 is guaranteed by us. Repairs when necesssary can be best handled by our own repair department. We do not recommend outside repair agencies.

If your Model 152 or any other instrument produced by us requires factory repair or recalibration, ship it directly to:

Accurate Instruments Co., Inc.

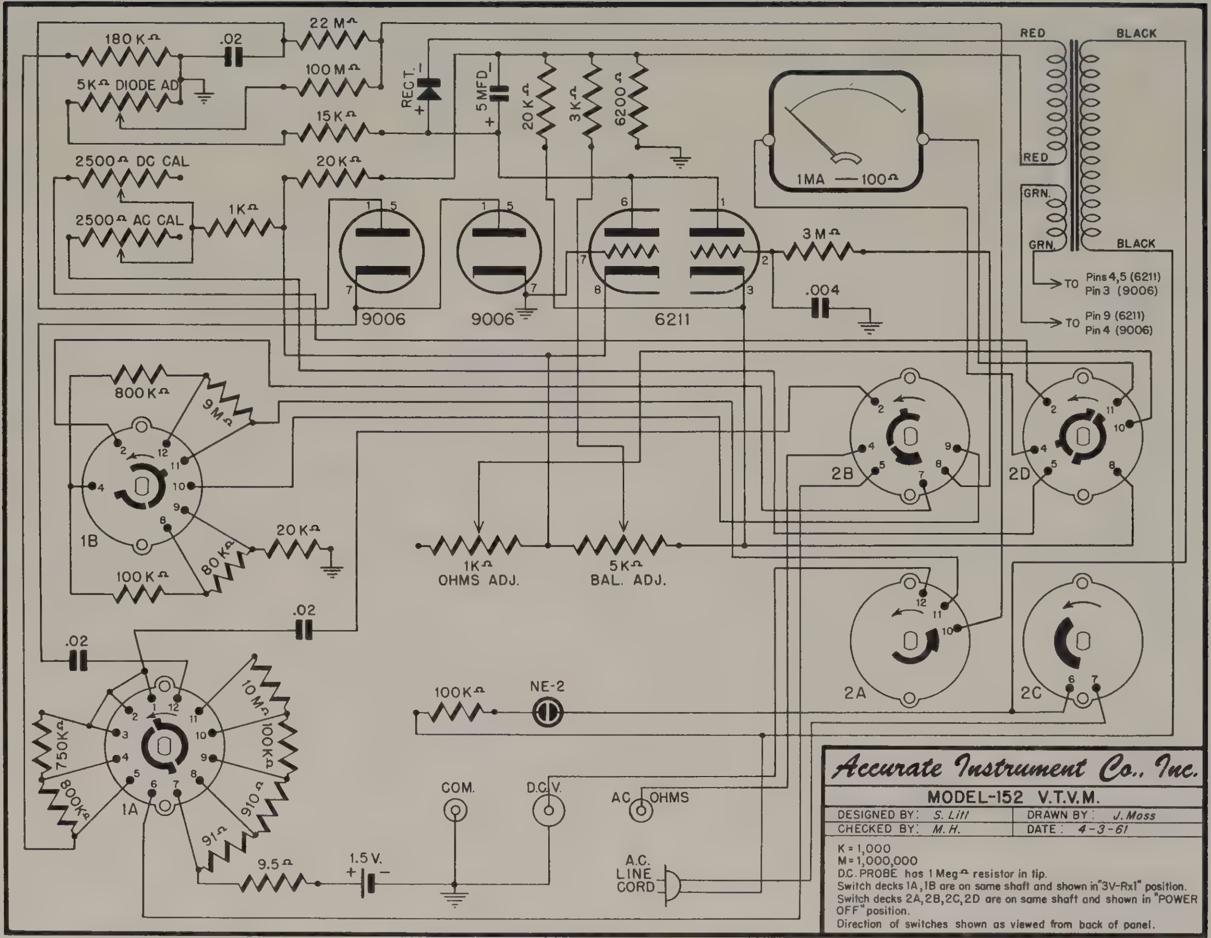
Repair Department

911 Faile Street

New York 59, New York

At the same time shipment is made, write to us separately (do not enclose letter in package) advising us of the date you shipped and reason for return.

After inspection, our Repair Department will repair your tester at no charge if not damaged through misuse or quote cost for repairs.


180 KΩ
.02
22 MΩ
100 MΩ
5KΩ DIODE AD
15 KΩ
RECT.
5 MFD
20 KΩ
3 KΩ
6200 Ω
1MA — 100Ω
RED
BLACK
RED
GRN.
GRN.
BLACK
TO Pins 4,5 (6211) Pin 3 (9006)
TO Pin 9 (6211) Pin 4 (9006)
2500Ω DC CAL
2500Ω AC CAL
20 KΩ
1KΩ
9006
9006
6211
3 MΩ
.004
800 KΩ
9MΩ
1B
20 KΩ
80 KΩ
100 KΩ
1KΩ OHMS ADJ.
5KΩ BAL. ADJ.
2B
2D
2A
2C
.02
.02
10 MΩ
100 KΩ
910 Ω
91Ω
750 KΩ
800 KΩ
1A
9.5 Ω
1.5 V.
100 KΩ
NE-2
COM.
D.C.V.
AC OHMS
A.C. LINE CORD

Accurate Instrument Co., Inc.

MODEL-152 V.T.V.M.

DESIGNED BY: S. Litt	DRAWN BY: J. Moss
CHECKED BY: M. H.	DATE: 4-3-61

K = 1,000
M = 1,000,000
D.C. PROBE has 1 MegΩ resistor in tip.
Switch decks 1A, 1B are on same shaft and shown in "3V-Rx1" position.
Switch decks 2A, 2B, 2C, 2D are on same shaft and shown in "POWER OFF" position.
Direction of switches shown as viewed from back of panel.

TRIPLETT

INSTRUCTION MANUAL

MODEL 3423

MUTUAL CONDUCTANCE
TUBE TESTER

[illegible]

3141 S.W. 26 Street Miami, Florida

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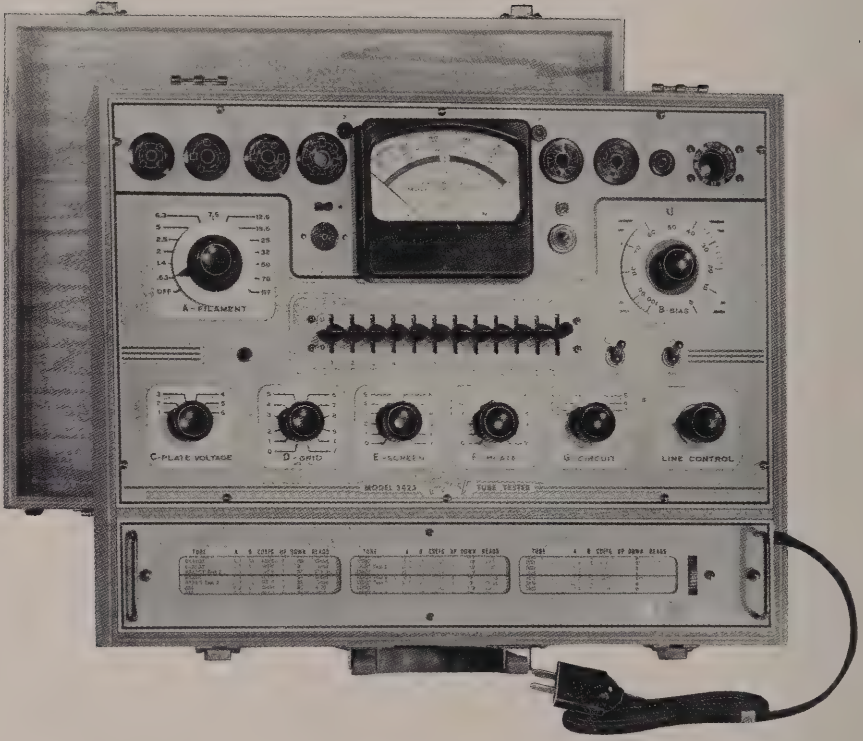
Wiring Diagram 12

Replaceable Parts 10-11

Warranty 13


6.3
5
2.5
2
1.4
.63
OFF
7.5
12.6
19.6
25
32
50
70
117
A-FILAMENT
B-BIAS
C-PLATE VOLTAGE
D-GRID
E-SCREEN
F-PLATE
G-CIRCUIT
LINE CONTROL
MODEL 3423
TUBE TESTER
TUBE A B CIRC'S UP DOWN READS

Model 3423

Model 3423 Specifications

TUBES TESTED	All types of receiving tubes, low power transmitting tubes, rectifiers, thyratrons, eye tubes, subminiature acorn, ballast tubes and pilot lamps. The continuity test circuit may also be used to check electrical appliances for shorts or open circuits. Separate plate tests on rectifiers and diode types.
CIRCUIT	Gm measured in micromhos under dynamic conditions. Employs actual signal oscillator (4KC) to produce grid signal. Special circuits for testing thyratron, eye tubes, and rectifiers with plate tied to cathode. Also includes a special circuit which will indicate gassy tubes. A high (36,000 micromhos) range for future tubes with high Gm values. Two signal voltages available.
RANGE	0-1800, 0-6000, 0-18,000, 0-36,000 micromhos. Good-Bad scale for emission tests. 0-100 scale for thyratron.
SHORT TEST	Applies low voltage to tube elements to prevent damage to tube. Shorts indicated on neon lamp.
FILAMENT VOLTAGES	.63, 1.4, 2.0, 2.5, 5, 6.3, 7.5, 12.6, 19.6, 25, 32, 50, 70, and 117 volts.
SOCKETS	4 prong, 5 prong, 6 prong, 7 prong large and small with combination for pilot lights and flashlight bulbs, 8 prong octal, 8 prong loctal, 7 prong miniature, 7 pin subminiature (for hearing aid tubes) 8 pin subminiature (round), 8 pin acorn, 9 pin subminiature.
TUBE CHART	Removable Roll Chart. Accessory compartment underneath.
CASE	Wood 14¾"x18 25/32"x6 13/32".
WEIGHT COMPLETE	21 pounds.
POWER	115 ACV, 50-60 cycles. Double fuses in line card.
ACCESSORIES	One red and one black top cap head included in tester.

General Description

Mutual conductance has been a common rating applied to tubes for many years. Unfortunately, the equipment required to give actual mutual conductance readings at specified operating conditions has been so complicated and bulky that testing has been confined to manufacturers and laboratories. Portable testing equipment has generally been confined to elementary tests or to hybrid circuits which obviously do not duplicate conditions under which the tube was originally rated.

To provide a portable tube tester which more nearly duplicates the basic requirements of mutual conductance, the Model 3423 has been developed. The circuit consists of a straight forward system of applying an audio signal (4KC) to the grid and detecting the effects of this signal in the output by a timed indicator. Hybrid or trick circuits are thus eliminated and the deviation from laboratory practise essentially reduces to the proportion of ideal conditions imposed on the tube. While each tube may not operate at identical conditions to those of the original rating, it is possible to produce conditions which yield proportional readings.

The use of a 4KC signal on the grid and timing the output indicating circuit eliminate the possibility of false readings from pick-up of the 60-cycle line frequency. Actually, it has been found that with this method 60-cycle voltages can be applied to the plate and screen without disturbing the proportional readings.

Five different plate and screen potentials are used which permit closer approximation to original rating conditions than is possible in hybrid circuits where only one voltage is available.

The detecting circuit is isolated from the normal plate current since it is responsive only to the 4KC component. Tubes of widely varying plate current requirements can therefore be effectively tested.

Two grid signals one of .6, the other 1.2 volts are employed. Overloading of the grid is avoided while retaining an extremely wide range of Gm readings.

To obtain accurate readings under different line voltages, a compensation knob is provided in the panel. Correct compensation is indicated on the meter and can be continuously adjusted during the testing procedure.

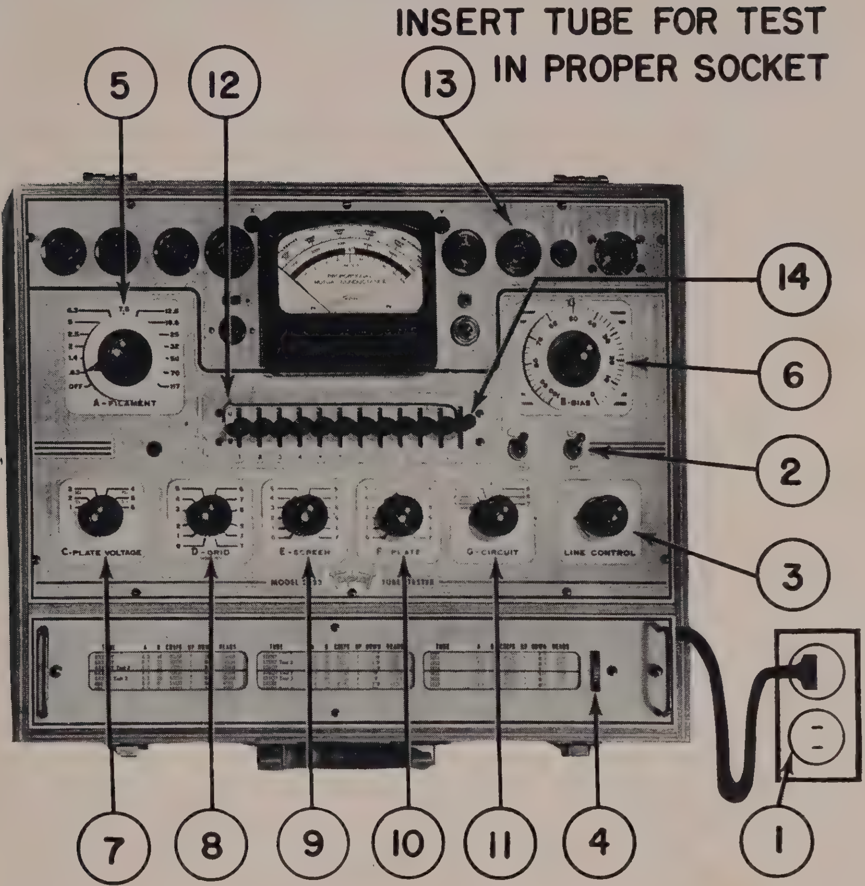
Diode tubes are of course tested for their emission characteristics since no mutual conductance is involved. Proper voltages are used to avoid overload.

Low power thyratrons are tested for their actual striking condition.

Lever switches connect each socket pin individually thus allowing extreme flexibility for setting up new tubes as they are announced.

The roll chart is removable for convenient replacement of chart as new listings are made. The compartment serves also as a place for accessories and small tools.

Operating Instructions


INSERT TUBE FOR TEST IN PROPER SOCKET
5
12
13
14
6
2
3
7
8
9
10
11
4
1
A-FILAMENT
B-BIAS
C-PLATE VOLTAGE
D-GRID
E-SCREEN
F-PLATE
G-CIRCUIT
LINE CONTROL
MODEL
TUBE TESTER

FIRST MAKE SHORT TEST — SETTING CONTROLS

1. Insert power cord into a 110 volt AC 60 cycle outlet.
2. Turn line switch to ON position.
3. Set "Line Control" so meter pointer will rest over "Line test" mark.
4. Set roll chart to type tube to be tested.

   Example

	A	B	C D E F G	UP	DOWN	READS
6AU5	6.3	36	5 1 8 5 2	7	123	6000

5. Set filament switch "A" as shown in column "A" on chart.
6. Set control "B" as shown in column "B" on chart.
7. Set all levers UP shown on chart and **all** remaining levers should be down **for short test only.**
   If there is a top cap or caps on the tube connect the "X" or "Y" top

cap lead to the top cap. Use X or Y according to roll chart (i. e. use X if X is noted on roll chart and Y if Y is noted). Two leads are provided with pin jacks to plug in at these jacks.

8. Insert tube in socket.
9. Set switch G-Circuit in number one short position.
10. Rotate "D-Grid" knob and tap tube at each position.

Shorted tube pins or those with internal connections are indicated by a steady bright red glow of the neon "Short Indicator" on the right side of the panel. Pin numbers in dark face type on the roll chart will indicate red glow, except as noted under certain tube type. Shorts or leaks less than 250,000 ohm will be indicated as short.

General note on Shorts Test

In multi-purpose tubes which require more than one test, it is only necessary to make one shorts test.

Position 7 on the "G Circuit" switch No. 11 which have the plate internally connected to the cathode or filament such types 117N7 and 117P7.

Gm VALUE TEST

Having completed the shorts test, set roll chart to type tube for test, "A" filament switch set correctly, "B" control set, and tube in socket. Now set all remaining controls and levers according to roll chart. Levers not mentioned in either up or down position should be in center position. If there is a top cap or caps on the tube connect the "X" or "Y" top cap lead to the top cap. Use X or Y accrding to roll chart (i. e. use X if X is noted on roll chart and Y if Y is noted). Two leads are provided with pin jacks in at these jacks

Example

Type	A	B	C	D	E	F	G	UP	DOWN	READS
6AU5										
Set Control	No. 5	6	7	8	9	10	11			
To	6.3	36	5	1	8	5	2	7	123	6000

After all controls and levers have been set readjust line control No. 3 so the pointer is over the line mark on meter. Hold value lever No. 14 in "Value" position and read meter.

The word "Good" on the roll chart means to read the tube value on the "Good-Bad" scale.

The special note under the control setting such as (Good tube reads 30) means to read 0-100 linear scale under the "Good-Bad" scale. The figure given is equal to 70 on the "Good" portion of the Good-Bad scale. A tube may read 25% low of figure given and be good.

For "G Circuit" position		Read Scale
	2	0-18,000 (10×1800)
	3	0-6,000
	4	0-1,800
"Normal Special" Switch in "Special" Position	2	0-36,000

GAS TEST (for amplifier tubes)

Set all controls as indicated on roll chart. "Normal-Special" switch should be in "Normal" position, unless special note is made on roll chart to use the "Special" position. If there is a top cap or caps on the tube connect the "X" or "Y" top cap lead to the top cap. Use X or Y according to roll chart (for example, use X if X is noted on roll chart and Y if Y is noted). Two leads are provided with pin packs to plug in at these jacks.

Set "G Circuit" or control No. 11 on number 4 position which is the 0-1800 micromhos range. Rotate "B-Bias" Control No. 6 until meter reads 300 on the 0-1800 scale. Hold lever switch No. 14 in "Value position while making the above adjustments. If 300 cannot be obtained set "B-Bias" for lowest obtainable value. Now move lever switch No. 14 to "Gas" position and note change in meter reading. If the reading changes plus or minus 1 division on the 0-1800 scale the tube is gassey.

THYRATRON VALUE TEST

Set all controls according to the roll chart.

If there is a top cap or caps on the tube connect the "X" or "Y" top cap lead to the top cap. Use X or Y according to roll chart (for example use X if X is noted on roll chart and Y if Y is noted).

Hold "Value" lever No. 14 in "Value" position and change "B-Bias" control from 100 to value shown on chart at which tube will fire i. e. "Tube strikes at 60-65 move "B-Bias" from 100 to 65 and note that tube fires between 60 and 65 and as soon as it has fired the meter should read in the good portion of "Good-Bad" scale or as noted on chart on the thyratron scale.

EYE TUBE TEST

Set all controls according to the roll chart.

If there is a top cap or caps on the tube connect the "X" or "Y" top cap lead to the top cap. Use X or Y according to roll chart (i. e. use X if X is noted on roll chart and Y if Y is noted). Two leads are provided with pin jacks to plug in at these jacks.

Hold "Value" lever in "Value" position and change "B-Bias" control from value shown on chart for eye closed to value shown for eye open and note proper indication on the eye tube. No meter reading is made on this test. For eye tubes with two sections a note is made on chart "Right section open."

FILAMENT CONTINUITY TEST

Repeat Short Test procedure. When the "D-Grid (short test)" selector is rotated to the position corresponding to the filament pin number which is noted on the roll chart **in dark face type,** a short should be indicated by a red glow of the neon short test lamp. This applies to center tap filament pin also. For those tubes with note "For filament continuity test" proceed as follows:

Follow the Short Test procedure above except turn the "A-Filament" switch to .63 volts. It is sometimes possible to obtain short tests on these tubes with the filament set at rated voltage, but the neon lamp may not glow bright enough for a positive check.

PILOT LIGHT TEST

Set "A-Filament" Switch No. 5 to the proper rated voltage of the lamp to be tested.

Insert the pilot lamp in the center of the 7 pin combination socket and lamp will glow when good.

CONTINUITY TEST FOR APPLIANCES

Set "G Circuit" Switch No. 11 to 1 or shorts position, rotate "D-Grid" Switch No. 8 to X position. Move "X" and "Y" levers to down position.

Connect leads to "X" and "Y" jacks and to circuit for continuity test. Continuity is noted if the neon lamp for short test glows.

Cross Reference To Type Tube

For information a cross reference listing of these tubes with two type numbers is given:

Tube Type	Listed Under	Tube Type	Listed Under
VR-75	OA3	CK568AX	CK5677
VR-90	OB3	CK569AX	CK5678
VR-105	OC3	CK605CX	CK5702
VR-150	OD3	CK608CX	CK5703
6A4	6A4/LA	1006	CK1006
6Q5	884	1203-A	7C4/1203A
6U5	6G5	1232	7G7
14A7	12B7/14A7	1852	6AC7
12Z5	6Z5	1853	6AB7
25S	1B5	2523NI	128A/2523NI
44	39	8016	1B3
40Z5	45Z5	AS	57AS/57A
51	35	ECL-80	6AB8
82V	82	EF-80	6BX6
G84	2Z2	KR-1	1V
99	X99	KR-5	6A4/LA
482-B	182-B	KR-25	2A5
483	183	KR-98	6Z4/84
GL-502-A	502-A	PL-83	15A6
585	50	XXB	3C6
879	2X2	XXD	14AF7
951	1B4P	XL	7A4

Adapter for TV Picture Test

With the BV Adapter Model 3423 will test TV Picture tubes. A picture tube can be tested right in the shipping carton or in the receiver without removing the tube from receiver. A time saver and safety factor.

Data for setting tester is supplied wih the adapter part number 2247-A-BV.

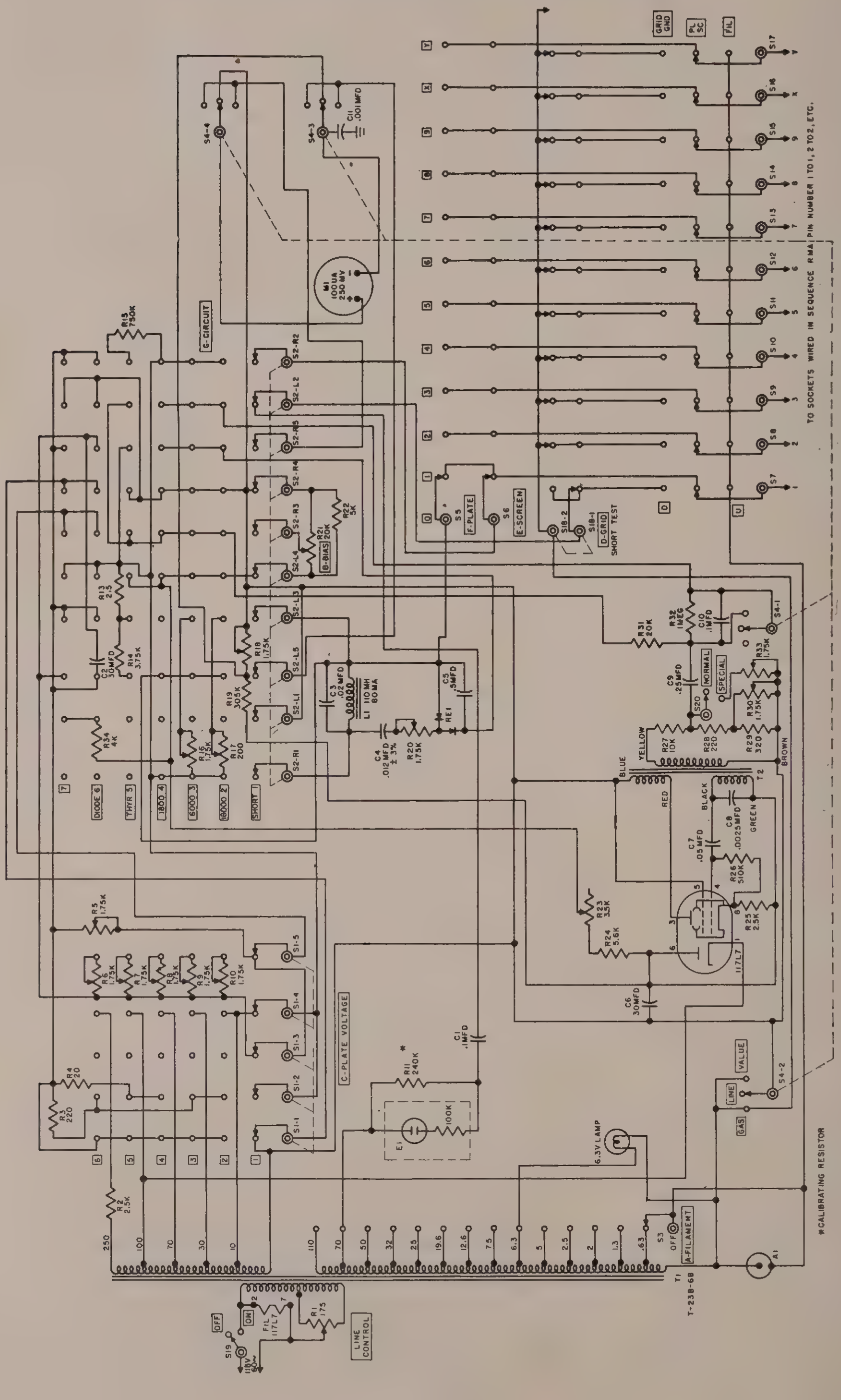
Replaceable Parts, 3423

Ref. No.	Quan.	Part Name	Description	Triplett Part No.
C1	1	Capacitor	.1 MFD-400 WVDC	T-2631-P27
C2-C6	2	Capacitor	30 MFD-150 WVDC	T-43-103
C3	1	Capacitor	.02 MFD-400 WVDC	T-43-67
C4	2	Capacitor	.006 MFD-400 WVDC ±3%	T-43-116
C5	1	Capacitor	.5 MFD-200 WVDC	T-43-108
C7	1	Capacitor	.05 MFD-200 WVDC	T-2631-P3
C8	1	Capacitor	.0025 MFD-Mica ±5%	T-43-109
C9	1	Capacitor	.25 MFD-400 WVDC	T-43-38
C10	1	Capacitor	.1 MFD-200 WVDC	T-2631-P1
C11	1	Capacitor	.001 MFD-Ceramic	T-43-74
R1	1	Resistor	175 ohm, variable	8595
R2	1	Resistor	2.5 K ohms, 10 W ±5%	T-15-873
R3	1	Resistor	220 ohms, ½W, ±10%	T-2601-1/2-220
R4	1	Resistor	20 ohms, ½W, ±10%	T-15-1426
R5, 6, 7, 8, 9, 10, 16,18,20, 30, 33	11	Resistor	1.75 K ohms, Variable ±20%	T-16-62
R13	1	Resistor	2.5 ohms, W. W. ±1%	T-15-1976
R14	1	Resistor	3750 ohms, 1 W, ±1%	T-15-1857
R15	1	Resistor	750 K ohms, ½W, ±10%	T-15-1801
R17	1	Resistor	200 ohms, Variable ±10%	T-16-86
R19	1	Resistor	305 K ohms, ½W, ±1%	T-15-1856
R21	1	Resistor	20 K ohms, Variable 2W, ±5%	T-16-98
R22	1	Resistor	5 K ohms, 1W, ±1%	T-15-912
R23	1	Resistor	3.5 K ohms, Variable ±10%	T-16-90
R24	1	Resistor	5.6 K ohms, 2W, ±10%	T-15-2306
R25	1	Resistor	2.5 ohms, W. W., ±1%	T-15-2210
R26	1	Resistor	510 K ohms, ½W, ±10%	T-2601-½-510K
R27	1	Resistor	10 K ohms, 1W, ±1%	T-15-856
R28	1	Resistor	220 ohms, 2W, ±5%	T-15-1798
R29	1	Resistor	320 ohms, ½W, ±10%	T-2601-½-320
R31	1	Resistor	20 K ohms, ±10%	T-2601-½-20K
R32	1	Resistor	1 meg. ½W	T-2601-½-1 meg
R34	1	Resistor	4 K ohms, 1W, ±1%	T-15-911
		Socket	4 hole, black	T-2455-126
	1	Socket	5 hole, black	T-2455-127
	1	Socket	6 hole, black	T-2455-125
A-1	1	Socket	7 hole, black with pilot socket	T-2455-130
	1	Socket	8 hole, black, actal	T-2455-128
	1	Socket	8 hole, black, octal	T-2455-129
	1	Socket	9 hole, miniature, black	T-2455-92
	1	Socket	7 hole, miniature, black	T-2455-59
	1	Socket	7 hole, subminiature	T-2455-80
	1	Socket	Acorn, black	T-2455-159
	1	Socket	8 hole, mica, subminiature	T-2455-122
	1	Socket	8 octal, for tube mtg.	T-2455-82
S1	1	Switch	14 pos, 5 deck, 6 active	T-22B-230
S2	1	Switch	20 pos, 5-2 pole decks, 7 active	T-22B-235
S3	1	Switch	20 pos, 1 deck, 15 active	T-22A-234
S4	1	Switch	3 pos, 4 pole, lever, spring return to center	T-22A-202
S5-6	2	Switch	14 pos, 1 deck	T-22A-233
S7-17	10	Switch	3 pos, lever	T-22A-229
S-18	1	Switch	12 pos, 2 deck	T-22A-161
S-19-20	2	Switch	Toggle, bat handle SPST	T-22-116
T1	1	Transformer	Power	T-23B-68
T2	1	Transformer	Audio	T-23-17A
	1	Tube	117L7/N7GT	T-2600-117L7

Replaceable Parts, 3423

Ref. No.	Quan.	Part Name	Description	Triplett Part No.
L1	1	Choke	110 MH œ 80 ma	T-3022B-28
	1	Jack	Black	7922
	1	Jack	Red	7923
	1	Lamp	Assembly, pilot red	T-67-70
	1	Lamp	6-8 V Bayonet base	T-67-65
	1	Plug	for line cord	T-2455-136
	1	Cord	Line 7 ft.	T-2566-48
M1	1	Instrument	100uA, 250 MV	T-52-392
	2	Fuse	2 Amp	10423
	1	Lamp	Neon NE. 51 bayonet base	T-3024-3
E1	1	Lamp Assem	Clear neon with built in resistor	T-67-76
	6	Knobs	1¼ round x ⅝ high	T-34-40
	2	Lead Assem.	1 red, 1 black, 15½″ L	T-79A-135
RE-1	1	Rectifier	Conant, BHS 3 lead	9686
	1	Roll Chart	Paper printed 72″ L x 14″ W	T-84-37-( )
	1	Assembly	Roll chart	10647A
	1	Case	Oak	T-10A-1129
	11	Knobs	Round, black (11 springs T-42-116)	T-34-37

Wiring Diagram, Model 3423


G-CIRCUIT
M1 100UA 250 MV
S4-4
S4-3
C11 .001MFD
R15 750K
S2-R2
S2-L2
S2-R5
S2-R4
S2-R3
S2-L4
S2-L3
S2-L5
S2-L1
S2-R1
R21 20K
B-BIAS
R22 5K
R18 1.75K
R19 305K
R16 1.75K
R17 200
R13 2.5
R14 3.75K
C2 30MFD
R34 4K
7
DIODE 6
THYR 5
1800 4
6000 3
18000 2
SHORT 1
C3 .02MFD
L1 110MH 80MA
C5 .5MFD
RE1
C4 .012MFD ± 3%
R20 1.75K
S5
F-PLATE
S6
E-SCREEN
S18-2
S18-1
D-GRID
SHORT TEST
GRID GND
PL SC
FIL
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
U
D
R31 20K
R32 1MEG
C10 .1MFD
S4-1
C9 .25MFD
NORMAL
SPECIAL
R33 1.75K
S20
R30 1.75K
R27 10K
R28 220
R29 320
YELLOW
BROWN
BLUE
RED
BLACK
GREEN
T2
C8 .0025MFD
C7 .05MFD
R26 510K
R25 2.5K
R23 3.5K
R24 5.6K
117L7
C6 30MFD
R5 1.75K
R6 1.75K
R7 1.75K
R8 1.75K
R9 1.75K
R10 1.75K
S1-5
S1-4
S1-3
S1-2
S1-1
C-PLATE VOLTAGE
C1 .1MFD
R11 240K *
100K
E1
R4 20
R3 220
R2 2.5K
6.3V LAMP
VALUE
LINE
GAS
S4-2
250
100
70
30
10
110
70
50
32
25
19.6
12.6
7.5
6.3
5
2.5
2
1.3
.63
S3
OFF
A-FILAMENT
A1
T1
T-238-68
OFF
ON
S19
110V 60~
FIL 117L7
R1 175
LINE CONTROL

TO SOCKETS WIRED IN SEQUENCE RMA PIN NUMBER 1 TO 1, 2 TO 2, ETC.

*CALIBRATING RESISTOR

WARRANTY FOR RADIO AND TELEVISION INSTRUMENT AND TEST EQUIPMENT

(Including Maintaining Parts of Discontinued Models)

Adopted and Recommended by the Radio-Television Manufacturers Association, 1951

The Triplett Electrical Instrument Company warrants instruments manufactured by it to be free from defective material or factory workmanship and agrees to repair such instruments which under normal use and service, discloses the defect to be the fault of our manufacturing. Our obligation under this warranty is limited to repairing any instrument or test equipment which proves to be defective, when returned to us, transportation prepaid, within ninety (90) days from the date of original purchase and provided the serial number has been made known to us promptly for our records.

This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons or service stations in any way so as, in our judgment, to injure their stability or reliability or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced, or removed. Neither does this warranty apply to any of our products which have been connected, installed, or adjusted otherwise than in accordance with the instructions furnished by us. Accessories including all vacuum tubes not of our manufacture used with this product are not covered by this warranty.

This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

Parts will be made available for a minimum period of five (5) years after the manufacture of this equipment has been discontinued. Parts include all materials, charts, instructions, diagrams, accessories, et cetera, which have been furnished in the standard model.

RED-DOT LIFETIME GUARANTEE

The Red-Dot Lifetime Guarantee made only by Triplett warrants the meter to be free from defects in material and workmanship for the life of its original user.

The Triplett Electrical Instrument Company
Bluffton, Ohio

NOTES

NOTES

The Triplett Electrical Instrument Co.
Manufacturers of
PRECISION MEASURING INSTRUMENTS
Bluffton, Ohio

Printed in U. S. A. Part No. T-84-13-043053

eigh, NC 27602

ce.

983

ower used for
e hour.

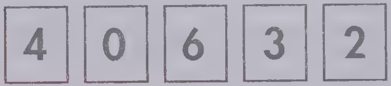
nsumption recorded
y billing period.

that the registration be
ge. Only meter constants

returned for insufficient funds.

How to read your electric meter

Meters are read left to right. This illustration reflects 40632.



Important safety reminders

- Avoid all contact with electric wires. Exercise care when using ladders or poles outdoors.
- Never go near downed power lines. To report dangerous lines, call **1.800.419.6356**.
- Activity near power lines can be life-threatening. Please use caution, and hire professionals when appropriate. Remember that tree limbs conduct electricity.

Important credit information

Deposit waiver decisions are based on your payment history with Progress Energy or on information from your Experian consumer credit bureau file. Waiver decisions are made by Progress Energy, not Experian. Under the Federal Fair Credit Reporting Act, you can receive a free copy of this information by contacting Experian at **1.800.804.5901** or by mail: Experian, P.O. Box 2104, Allen, TX 75013. You have the right to ask Experian to reinvestigate your credit information and send us updated credit report for re-evaluation.

- NO PAGE #'s
- IN proper order

OK

1984

ISASI

CHANGE/ERRATA INFORMATION

ISSUE NO: 2 3/90

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCB is equal to or higher than that given with each change.
2. No revision letter is indicated at the beginning of the change/errata.

ERRATA #1

On page 1, change the first bulleted paragraph as follows:

FROM: o ..... of all readings taken over a period as long as twenty-four hours, ... ✓

TO: o ..... of all readings taken over a period as long as thirty-six hours, ... ✓

On page 10, change the first paragraph as follows:

FROM: The true average of all the readings taken over at least a thirty-five hour period .... ✓

TO: The true average of all the readings taken over at least a thirty-six hour period .... ✓

Beckman Industrial™

CIRCUITMATE™ MODEL DM73
DIGITAL MULTIMETER

Operator's Manual
Mode d'emploi
Bedienungsanleitung

Ser #
50204265

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INSTRUMENTATION PRODUCTS DIVISION
BECKMAN INDUSTRIAL CORPORATION
A SUBSIDIARY OF EMERSON ELECTRIC CO.
BREA, CA 92621

Beckman Industrial Corp. Brea, CA 92621
JAN. 1985 3000-940-180 Printed in Japan

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On page 10, change the first paragraph as follows:

FROM: The true average of all the readings taken over at least a thirty-five hour period .... ✓

TO: The true average of all the readings taken over at least a thirty-six hour period .... ✓

Note: Le symbole à l'avant du DM73 renvoie l'utilisateur au mode d'emploi.

Description

Le DM73 est un multimètre numérique de type à sonde qui permet de mesurer à la fois la tension CC, la tension CA, la résistance et la continuité. Parmi les mesures et fonctions disponibles, on relève: un sélecteur de mode [tension (V), résistance ohmnique (Ω), tonalité de continuité (🔊)], fonction marche/arrêt, CC/CA et Maintien Affichage (DH). Très compact, cet appareil est aussi léger, ce qui le rend tout à la fois facile à utiliser et facile à transporter.

Précautions

① Pour éviter les risques d'électrocution, commuter le multimètre sur arrêt et déconnecter les fils reliant le multimètre à l'appareil contrôlé avant le retrait du cache de batterie ou le démontage de l'appareil.
② Les tensions supérieures à 24 volts CA ou CC sont dangereuses. Redoublez de prudence si le travail se fait sur ou à proximité de telles sources de tension.
③ Pour éviter les risques d'électrocution et/ou protéger le multimètre de dommages éventuels, ne pas mesurer des tensions susceptibles de dépasser 500 volts au dessus de la mise à la terre.
④ A chaque utilisation de l'instrument, vérifier si l'isolant du coffret et de la sonde n'est pas fêlé ou fracturé. En cas de dégâts, remplacer l'élément endommagé dans les plus brefs délais. Ne jamais utiliser cet appareil lorsqu'il est endommagé!
⑤ Pour éviter les risques de commotion électrique, ne pas toucher l'extrémité des fils d'essai ou le circuit en cours d'essai alors que l'alimentation électrique est fournie.
⑥ Attention! La mesure de sources d'alimentation secteur avec des fils inductifs ou pendant un orage risque de s'accompagner de transitoires de haute tension qui endommageraient le multimètre et constitueraient pour l'utilisateur une source de commotion électrique très dangereuse.
⑦ Redoublez de prudence lorsque l'essai porte sur un transformateur à tension constante car l'éventualité d'un circuit ouvert pourrait engendrer une tension supérieure à la tension nominale limite (500 volts).
⑧ Attention! Si la charge excède la limite préconisée, le multimètre risque de subir des dommages.

Mode d'emploi

Note: Lors du branchement/débranchement des fils d'essai sur/à partir d'un circuit, ne pas oublier de commuter préalablement le circuit sur arrêt et décharger toutes les capacitances.

Mesure de tension CC et CA

Placer le sélecteur de mode en position "V" et le sélecteur AC/DC (CA/CC) à la position souhaitée (AC est visible sur l'affichage). Relier l'instrument au circuit et lire la tension indiquée sul L'affichage.

Mesure de résistance ohmnique

Placer le sélecteur de mode en position "Ω", relier l'instrument à la résistance et lire la valeur portée à l'affichage. Si les résistances mesurées sont élevées, attention à ne pas mettre en contact l'isolant et les fils d'essai.

Mesure de continuité

Placer le sélecteur en position "🔊", relier l'instrument au dispositif ou au fil à contrôler. La tonalité retentit lorsque la continuité est établie (résistance < 100Ω). La tonalité retentit également à chaque permutation du sélecteur de mode ou lorsque les gammes de mesure du multimètre sont permutées.

Maintien Affichage

L'affichage peut être "figé" sur une valeur quelconque à condition que la touche Maintien Affichage (DH) soit pressée avant de débrancher l'instrument du dispositif soumis à essai. Pour rétablir le mode de fonctionnement normal, réappuyer sur cette touche.

Informations relatives à la garantie

Aux Etats-Unis, la période de garantie est de 90 jours. Pour de plus amples informations sur la garantie ou sur sa validité dans les autres pays, prière de contacter votre distributeur Beckman Industrial ou tout autre représentant agréé.

En cas de difficultés

Si le multimètre fonctionne mal, vérifier si les piles ne sont pas déchargées. Si la défaillance persiste, relire le mode d'emploi; l'éventualité que l'appareil n'est pas utilisé de la manière préconisée n'est pas à écarter d'emblée! Si malgré tout l'appareil ne marche pas. le renvoyer à l'usine pour réparation ou recalibrage éventuel. Pour tout complément de détails sur les réparations (couvertes ou non par la garantie), interrogez votre distributeur Beckman Industrial.

Expédition

Tout multimètre renvoyé à l'usine pour calibrage ou réparation doit être expédié avec les informations suivantes: nom de la société, nom du client, adresse, numéro de téléphone, pièce justificatives d'achat (réparations couvertes par la garantie), une description du problème ou du type d'entretien requis avec les charges d'entretien appropriées.

Pièces interchangeables par l'utilisateur

Couvercle de pile	3003-420-102
Extrémité de sonde	3003-450-100
Type de pile	SR44, LR-44 ou S76
Fil d'essai	3003-370-102

Accessoires

AL73	Fil d'essai avec pince crocodile
LC13	Etui en cuir
VC10	Etui en vinyl

SPECIFICATIONS Technische Daten
SPECIFICATIONS

DC VOLTS Gleichspannungen
VOLTAGE CC

Ranges	4 (2V...500V)	
Accuracy	2V	.5%+4dgt
	20, 200V	.7%+4dgt
	500V	1%+4dgt
Input Impedance	11M ohm (2V:12M ohm)	
Protection	700VDC or DC+peakAC for 60 sec.	

AC VOLTS Wechselspannungen
VOLTAGE CC

Ranges	4 (2V...500V)
Accuracy	1%+8dgt
Input Impedance	11M ohm (2V:12M ohm)
Protection	700VDC or DC+peakAC for 60 sec.

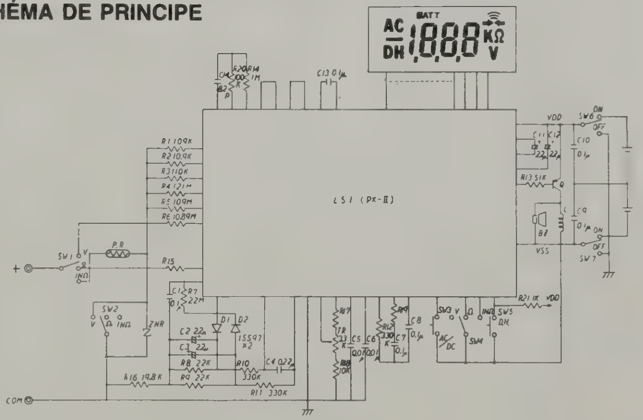
RESISTANCE Widerstände
RESISTANCE OHMNIQUE

Ranges	4 (2k...2M)	
Accuracy	2k...200k	.7%+4dgt
	2M	1.2%+4dgt
Max. voltage	.45V open circuit	
Protection	250VAC or DC for 60 sec.	

GENERAL Allgemeines
GÉNÉRALITÉS

Display	3 1/2 digit LCD
Measure rate	2/second nominal
Temp. range	0—40 degrees C
Batteries	2XLR44, SR44 or S76
Life	100 hours nominal

SCHEMATIC Schemadarstellung
SCHÉMA DE PRINCIPE



Beckman Industrial™

CIRCUITMATE™ MODEL DM73
DIGITAL MULTIMETER

Operator's Manual
Mode d'emploi
Bedienungsanleitung

Ser#
50204265

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INSTRUMENTATION PRODUCTS DIVISION
BECKMAN INDUSTRIAL CORPORATION
A SUBSIDIARY OF EMERSON ELECTRIC CO.
BREA, CA 92621

Beckman Industrial Corp. Brea, CA 92621
JAN. 1985 3000-940-180 Printed in Japan

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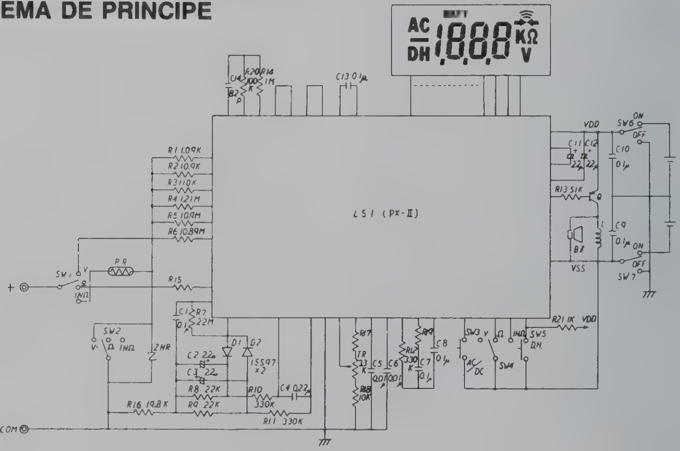

AC
DH
1888
KΩ
V
C13 0.1μ
C14 82P
R20 100K
R14 1M
R1 1.09K
R2 10.9K
R3 110K
R4 1.21M
R5 10.9M
R6 10.89M
PR
SW1 V
INΩ
+
R15
C1 0.1μ
R7 22M
SW2
V Ω INΩ
ZNR
D1 D2
1SS97 x2
C2 22μ
C3 22μ
R8 22K
R9 22K
R10 330K
C4 0.22μ
R11 330K
R16 19.8K
COM
LSI (PX-II)
R17
TR 33K
R18 10K
C5 0.01μ
C6 0.01μ
R19
R12 330K
C7 0.1μ
C8 0.1μ
SW3 V Ω INΩ
SW5 DH.
AC/DC
SW4
R21 1K
VDD
C11 22μ
C12 22μ
C10 0.1μ
SW6 ON OFF
R13 51K
Q
L
BZ
C9 0.1μ
VSS
SW7 ON OFF

MODEL 9071
PRECISE
VTVM

precise

INSTRUCTIONS:

MODEL 9071 VTVM

VOLTAGE REGULATED VTVM

PRECISE DEVELOPMENT CORPORATION
OCEANSIDE, NEW YORK

Note: The symbol ⚠ on the front of the DM73 means: "Refer to operating instructions".

Description

The DM73 is a probe-type digital multimeter capable of measuring DC and AC voltage, resistance and continuity. Its controls are: Mode [Volts (V), Ohms (Ω) or continuity Beeper (🔊)], On-Off, AC/DC and Display Hold (DH). The unit features small size and light weight, making it extremely easy to use and very portable.

Warnings

① To prevent electrical shock hazard, turn off the multimeter and disconnect the test leads from any device under test and from the multimeter before removing the battery cover or disassembling the unit.
② Voltages over 24 volts AC or DC can be hazardous. Use extreme care when working on or near such voltage sources.
③ To avoid electrical shock hazard and/or damage to the meter, do not attempt to measure voltages that might exceed 500 volts above earth ground.
④ Each time the instrument is to be used, examine the case and the test probe for cracks or breaks in the insulation. If defects are found, replace the item immediately. DO NOT USE IN A DAMAGED CONDITION.
⑤ To avoid electrical shock hazard, do not touch the test lead tips or the circuit being tested while power is applied to the circuit under test.
⑥ Measurement of AC power sources with inductive loads or AC power souces during electrical storms may result in extremely high-voltage, high-energy transients that could damage the meter and consequently expose the user to a dangerous shock hazard.
⑦ Extreme caution should be exercised when measuring constant-voltage transformers when an open-circuit may cause a voltage that exceeds the voltage ratings of the meter (500V).
⑧ Exceeding the maximum input overload limits can damage the multimeter.

Instructions for use

Note: When connecting or disconnecting test leads to or from a circuit, always first turn off power to the circuit under test and discharge all capacitors.

DC and AC voltage measurements

Set the mode switch to "V" and the AC/DC switch to the desired position (AC is shown in display). Connect the instrument to the circuit and read the measured voltage in the display.

Resistance measurements

Set the mode switch to "Ω". Connect the instrument across the resistance and read the value in the display. When measuring high resistance values, take care not to touch the insulation with the test leads.

Continuity measurements

Set the mode switch to " 🔊 ". Connect the instrument across the device or wire to be tested. Beeper will sound when continuity is established (R < 100Ω). The beeper also sounds briefly when shifting mode switch or when the instrument changes ranges.

Display Hold

The measurement shown in the display may be "held" if the Display Hold (DH) button is depressed before removing the instrument from the device under test. Pushing the button again will return the instrument to normal operation.

Warranty Information

In the United States, the limited warranty period is 90 days. For further warranty information or for the warranty period in other countrys, please contact your local Beckman Industrial distributor or authorized representative.

In case of difficulties

In the case of improper operation of the meter, first check the condition of the batteries, as the meter will not work properly with bad batteries. If this is not the problem, review the operating instructions for possible errors in operation. As a last resort, the meter may be returned for repair of calibration. Please contact your local Beckman Industrial Distributor or Beckman Industrial for information regarding in-and out-of-warranty repairs.

Shipping instructions

A multimeter returned for calibration or repair should be shipped with the following information or items: company name, customers name , address, telephone number, proof of purchase (warranty repairs), a description of the problem or service required, and the appropriate service charge.

User replacable parts

Battery cover	3003-420-102
Probe Tip	3003-450-100
Battery type	SR44, LR-44 or S76
Test lead	3003-370-102

Accessories

AL73	Test lead with alligator clip
LC13	Leather case
VC10	Vinyl case

Anmerkung: Das Symbol ⚠ auf der Vorderseite des DM73 bedeutet: "Siehe Bedienungsanleitung".

Beschreibung

Das DM73 ist ein Digital-Vielfachmeßgerät vom Sondentyp, mit dem Gleich- und Wechselspannungen, Widerstände und Kontinuität (Leitung) gemessen werden können. Es hat die folgenden Regler: Betriebsart [Volt (V), Ohm (Ω) oder Leitungspiepton (🔊)], Ein-Aqus, Gleich/Wechselstrom und Display-Arretierung (DH). Das Gerät ist klein und leicht und kann darum sehr leicht verwendet und transportiert werden.

Warnung

① Zur Vermeidung von elektrischen Schlägen das Vielfachmeßgerät und die Testkabel von allen gerade geprüften Geräten entfernen, bevor der Batteriefachdeckel abgenommen oder das Gerät auseinandergenommen wird.
② Spannungen von über 24 V Wechselstrom oder Gleichstrom können gefährlich sein. Bei der Arbeit mit oder in der Nähe von solchen Stromquellen äußerst vorsichtig sein.
③ Zur Vermeidung von elektrischen Schlägen und/oder Beschädigung des Vielfachmeßgerätes nicht versuchen, Spannungen von über 500 V über Erde zu messen.
④ Nach jeder Verwendung des Instrumentes das Gehäuse und die Testsonden im Hinblick auf Risse oder Brüche in der Isolation untersuchen. Wenn Schäden gefunden werden, das betreffende Teil sofort ersetzen. DAS INSTRUMENT NICHT IN SCHADHAFTEM ZUSTAND VERWENDEN.
⑤ Zur Vermeidung von elektrischen Schlägen nicht die Testkabelspitzen oder die gerade gemessenen Schaltungen berühren, während beim Test Strom an die Schaltungen angelegt ist.
⑥ Messungen von Wechselstromquellen mit induktiver Last oder Wechselstromquellen bei Gewitter kann extrem hochspannige, hochenergetische Stoßströme zur Folge haben, die das Vielfachmeßgerät beschädigenund entsprechend auch den Benutzer gefährden können.
⑦ Bei der Messung von Gleichstromtransformatoren größte Vorsicht walten lassen, wenn ein offener Stromkreis eine Spannung erzeugen kann, die den Spannungsbereich des Vielfachmeßgerätes überschreitet (500 V).
⑧ Überschreiten der Maximal-Eingangsbelastungsgrenze kann das Vielfachmeßgerät beschädigen.

Bedienungsanweisungen

Anmerkung: Bein Anschließen oder Abtrennen der Testkabel an oder von einem Stromkreis immer zuerst den Strom des untersuchten Stromkreises abstellen und alle Kondensatoren entladen.

Messung von Gleich- und Wechselströmen

Den Bentriebsartenschalter auf "V" stellen und den Gleich/Wechselstromschalter (AC/DC) in die gewünschte Position stellen (auf dem Display wird) dann z.B. AC angezeigt). Das Vielfachmeßgerät an den Stromkreis anschließen und die gemessene Spannung auf dem Display ablesen.

Messung von Widerständen

Den Betriebsartenschalter auf "Ω" stellen. Das Instrument über den Widerstand anschließen und den Wert auf dem Display ablesen. Bei der Messung von hohen Widerständen darauf achten, nicht die Isolierung mit den Testkabeln zu berühren.

Leitungsprüfung

Den Betriebsartenschalter auf " 🔊 " stellen. Das Instrument über dem zu prüfenden Gerät oder Draht anschließen. Der Piepton ertönt, wenn Leitung festgestellt wird (R < 100Ω). Der Piepton ertönt auch kurz, wenn der Betriebsartenschalter oder der Meßbereich des Instrumentes umgestellt wird.

Display-Arretierung

Die im Display gezeigten Neßwerte können "festgehalten" werden, wenn die Display-Arretierungstaste (DH) vor der Abnahme des Instrumentes von Testobjekt gedrückt wird. Durch erneutes Drücken der Taste wird das Instrument auf Normalbetrieb zurückgestellt.

Garantie-Information

In der USA gilt eine begrenzte garantiefrist von 90 Tagen. Garantie-Informationen über andere Länder erhalten Sie bei Ihrem örtlichen Beckman Industrial-Großhändler oder der nächsten Firmenvertretung.

Wenn Schwierigkeiten auftreten

Wenn das Vielfachmeßgerät nicht richtig funktioniert, prüfen Sie zunächst den Zustand der Batterien, da das Vielfachmeßgerät nicht richtig arbeitet, wenn diese zu schwach sind. Wenn dies nicht die Ursache der Störung ist, lesen Sie die Bedienungsanleitung erneut durch und prüfen Sie, ob das Gerät richtig bedient wurde. Wenn dies ebenfalls nicht der Fall ist, kann das Vielfachmeßgerät zur Reparatur oder Eichung eingegeben werden. Weitere Informationen über Reparaturen innerhalb oder nach Ablauf der Garantiefrist erhalten Sie bei Ihrem Beckman Industrial-Großhändler oder bei Beckman Industrial.

Versandanweisungen

Ein Vielfachmeßgerät, das zur Eichung oder Reparatur eingeschickt wird, muß mit den folgenden Informationen versehen sein: Firmenname, Kundenname, Anschrift, Telefonnummer, Kaufbeleg (bei Garantiereparaturen), eine Beschreibung des Problems oder der gewünschten Maßnahme sowie die entsprechende Kundendienstvergütung.

Vom Benutzer auszutauschende Teile

Batteriefachdeckel	3003-420-102
Sondenspitze	3003-450-100
Batterietyp	SR44, LR-44 or S76
Testkabel	3003-370-102

Zubehör

AL73	Testkabel mit Krokodilklemme
LC13	Ledertasche
VC10	Vinyltasche

precise

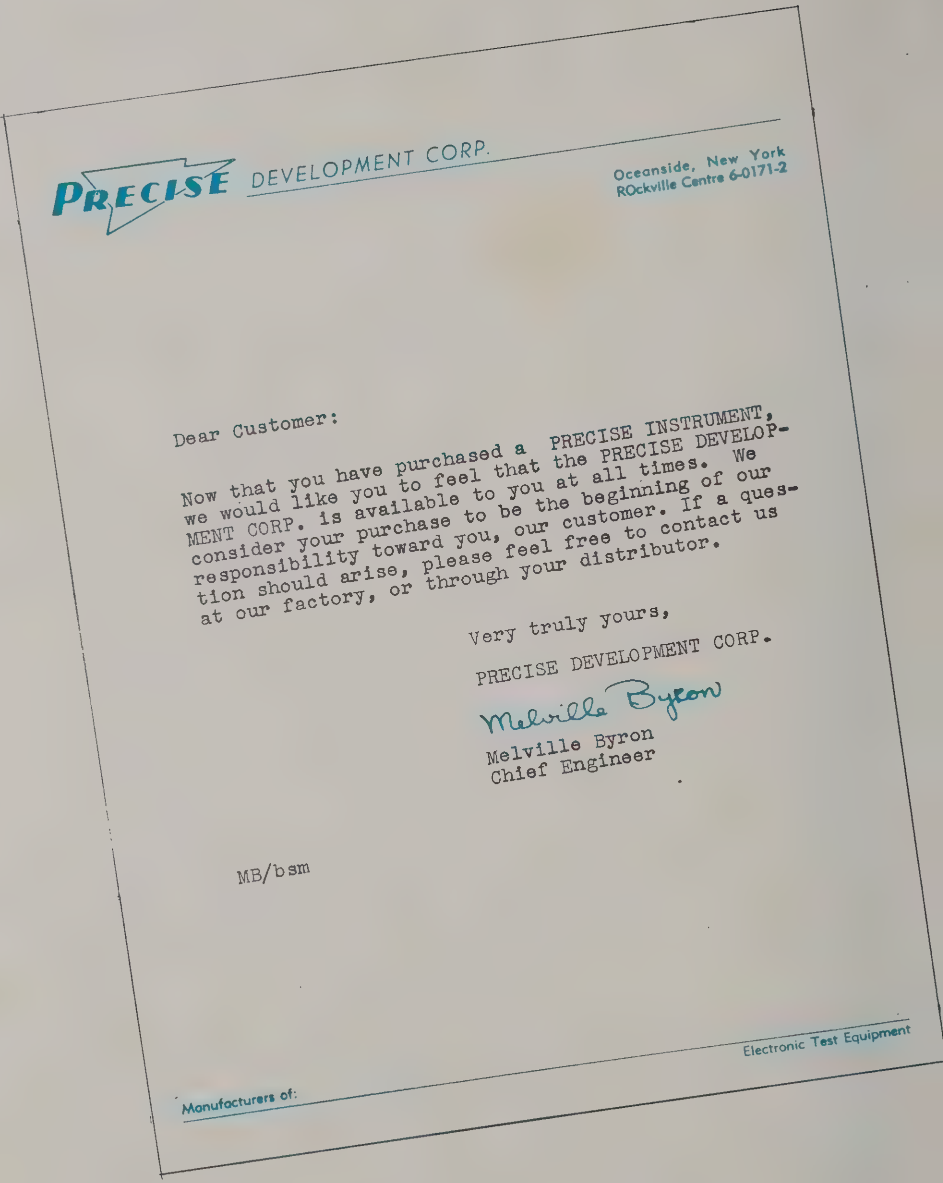
MODEL 9071
PRECISE

INSTRUCTIONS:

MODEL 9071 VTVM

VOLTAGE REGULATED VTVM

PRECISE DEVELOPMENT CORPORATION
OCEANSIDE, NEW YORK



PRECISE DEVELOPMENT CORP.
Oceanside, New York
ROckville Centre 6-0171-2

Dear Customer:

Now that you have purchased a PRECISE INSTRUMENT, we would like you to feel that the PRECISE DEVELOPMENT CORP. is available to you at all times. We consider your purchase to be the beginning of our responsibility toward you, our customer. If a question should arise, please feel free to contact us at our factory, or through your distributor.

Very truly yours,

PRECISE DEVELOPMENT CORP.

Melville Byron

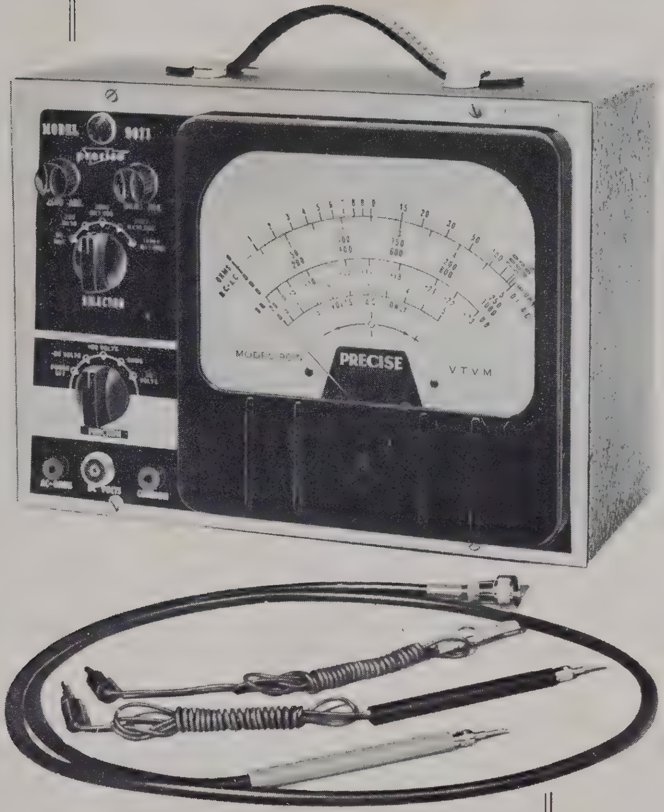
Melville Byron
Chief Engineer

MB/bsm

Manufacturers of: Electronic Test Equipment

construction book

MODEL 9071 VTVM


MODEL 9071
precise
SELECTOR
MODEL 9071
PRECISE
VTVM

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PRECISE DEVELOPMENT CORP.
Oceanside, L. I., N. Y.

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C B-9071-3-2641

INTRODUCTION:

The construction of an instrument from its kit form, is as important as any of the major components used within the instrument. Realizing this, the PRECISE DEVELOPMENT CORP. used extreme care in the preparation of this construction book, with such inovations as two-color pictorials and photographs, plus schematic diagrams. Above all, this basic construction was made as a simple series of steps which may readily be followed by even the most inexperienced person. If a moderate amount of care is used, and the instructions are carried out step-by-step, there is little possibility of ending with anything other than a truly professional piece of equipment. PRECISE certainly appreciates the anxiety felt by the constructor and has therefore taken every intelligent short-cut to reduce the construction time, but do not try to go too quickly. Care is your assurance of an instrument with many years of fine service ahead.

WIRING TECHNIQUE:

The charts and pictorials on the following pages have been prepared to show both the points to which a wire should be connected and the way to route the wire. The routing at first may not seem important, but at high frequencies it is of major concern. It also reduces the undesireable effects of distributed capacity and inductance. For these reasons do not cable leads.

SOLDERING:

Excessive heat will adversely effect parts by causing them to either change value, loose their protective coating or actually break down. To avoid this hold the tip of a pair of longnose pliers on the lead between the part and the junction that is being soldered. The pliers will conduct a sufficient amount of heat away to prevent damage.
Too little heat applied to connections may cause what is technically called a 'rosin joint'. These may simply be avoided by making certain that the solder flows and that all the flux has been 'burned-off'. The resulting contact should be smooth and shiny. A 'rosin joint' will often appear pitted, grey, and show the dark brown rosin in the connection proper. Although rosin is very important in the basic soldering process, and NO OTHER type of flux should be used, it can cause trouble by leakage between contacts. This may give rise to inaccurate readings, especially in the case of switches where rosin flowing between contacts develops leakage. Rosin may be removed by briskly going over the area with a stiff brush that has been saturated with carbon-tetrachloride. Be very careful not to spring the contacts when cleaning switches.

PARTS LIST:

The following pictorials, and parts list should be checked to both familiarize the constructor with each of the parts used, and to make certain of actual count. The incorporation of a check balance system at PRECISE makes it unlikely that any of the parts should be missing. If a discrepancy does occur, however, please write and action will be taken immediately. Since resistors and condensers are often color coded, rather than marked directly, the standard RMA Color Code is reprinted in this manual. It should be retained for future use.
In order to maintain a continuous supply of parts, orders are placed with several reputable manufacturers at the same time. You may find, therefore, that the parts list calls for a particular value although another is supplied. The substituted part will work equally well inasmuch as the circuit has a normal 20% tolerance. i.e. a 39K resistor may be substituted for a 47K resistor without altering the circuit operation. This, of course, does not apply to precision parts.

ADDENDA:

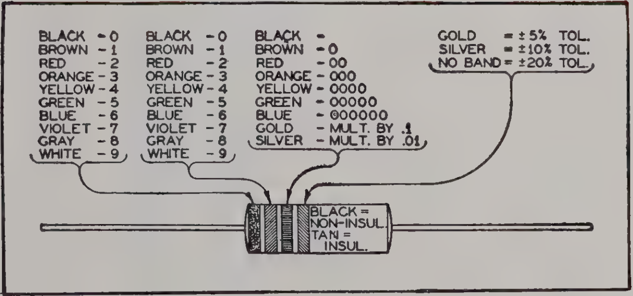
Please see addenda, in rear of this book, before proceeding with the actual construction.

CHECK	DESCRIPTION	PART #	AM'T	REMARKS
	Pilot Light & Bracket	B-1	1	
	.01 ufd Cond.	C-1, C-2, C-5	3	
	.0015 ufd Cond.	C-3	1	
	24 ufd Cond.	C-4	1	
	3/8" I.D. Hex Nut	H-2	9	
	3/8" I.D. Lockwasher	H-3	9	
	Octal Wafer Socket	H-4	1	
	6-32x½" Screw	H-5	1	
	6-32 Palnut	H-6	13	
	6-32 x ¼" Screw	H-7	12	
	7 Pin Miniature Wafer Socket	H-8	1	
	Small Machine Screw	H-9	4	
	Small Hex Nut	H-10	4	
	Small Lockwasher	H-11	4	
	4 Lug Terminal Strip	H-12	1	
	Chassis Connector	H-13	1	
	Banana Jack	H-14	1	
	¼" I.D. Lockwasher	H-15	1	
	¼" I.D. Hex Nut	H-16	1	
	Battery	H-17	1	
	Jewel Light	H-18	1	
	½" I.D. Hex Nut	H-19	1	
	Pin Jack & Star Washer	H-20	1	
	Octal Moulded Socket	H-21	1	
	#6 Solder Lug	H-22	1	
	Panel	H-23	1	
	Chassis	H-24	1	
	7 Pin Min. Moulded Socket	H-25	1	
	Handle Brackets	H-26	2	
	Meter Solder Lug	H-27	2	
	Phone Tip Plug	H-28	1	
	Alligator Clip	H-29	1	
	Black Test Prod	H-30A	1	
	Red Test Prod	H-30B	1	
	Spaghetti	H-31	1	
	Microphone Connector	H-32	1	
	Banana Plug	H-33	1	
	#8 Lockwasher	H-34	4	
	Self-Tapping Screw	H-37	5	
	Leather Handle	H-38	1	
	Cabinet	H-39	1	
	Battery Bracket	H-40	1	
	Cable Clamp	H-41	1	
	Pointer Knob	H-42	2	
	Round Knob	H-43	2	
	Meter	M-1	1	
	8M ohm Res.*	R-1	1	
	1.8M ohm Res.*	R-2	1	
	.1M " " *	R-3	1	
	50K " " *	R-4, R-5	2	
	15M " "	R-7	1	
	5.6M Res.	R-8	1	
	820K ohm Res.	R-9	1	
	1.5M " "	R-10	1	
	2M ohm potentiometer	R-11	1	
	1.5M ohm Res.	R-12	1	
	3.9M " "	R-13	1	
	1.5M " "	R-14	1	
	100K " "	R-15	1	
	10 ohm Res.*	R-16	1	
	100 " " *	R-17	1	
	10K " " *	R-18	1	
	2K ohm potentiometer	R-19	1	
	" " " "	R-20	1	If 3/8" long bushing is used, add 1-H2.
	1.2M ohm Res.	R-21	1	
	470 " "	R-22	1	
	2K ohm potentiometer	R-23	1	If 3/8" long bushing is used, add 1-H2
	470 ohm Res.	R-24	1	
	2K ohm potentiometer	R-25	1	
	" " " "	R-26	1	
	4.7K ohm Res., 1 watt	R-27	1	
	10K ohm Res., 1 watt	R-28	1	
	4.7K ohm Res., 1 watt	R-29	1	
	3 Pole-5p Switch (1 wafer)	S-1	1	If 3/8" long bushing is used, add 1-H2
	6 Pole-5p Switch (2 wafer)	S-2	1	
	Power Transformer	T-1	1	
	6AL5 Tube	V1, V2	1	
	6SN7 "	V3, V4	1	
	6X5 "	V-5	1	
	OA2 "	V-6	1	
	Wire, Hookup	W-1	1	
	Line Cord	W-2	1	
	Test Lead Wire	W-3	2	
	Coaxial Lead	W-4	1	
	Instruction & Construction Book		1	

* indicates PRECISION CERAMIC or WIREWOUND resistors. NOTE: Certain components may have hardware already attached-these should be included in count. I.D. means Inside Diameter.

RMA Color Code STANDARD

RESISTORS


BLACK - 0
BROWN - 1
RED - 2
ORANGE - 3
YELLOW - 4
GREEN - 5
BLUE - 6
VIOLET - 7
GRAY - 8
WHITE - 9

BLACK - 0
BROWN - 1
RED - 2
ORANGE - 3
YELLOW - 4
GREEN - 5
BLUE - 6
VIOLET - 7
GRAY - 8
WHITE - 9

BLACK -
BROWN - 0
RED - 00
ORANGE - 000
YELLOW - 0000
GREEN - 00000
BLUE - 000000
GOLD - MULT. BY .1
SILVER - MULT. BY .01

GOLD = ±5% TOL.
SILVER = ±10% TOL.
NO BAND = ±20% TOL.

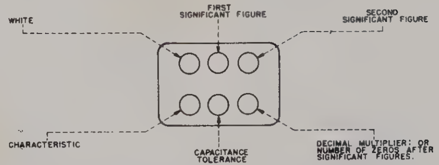
BLACK = NON-INSUL.
TAN = INSUL.

$\frac{1}{2}$ WATT

I WATT

MICA CAPACITORS

RMA REC 115 COLOR CODE


WHITE
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
CHARACTERISTIC
CAPACITANCE TOLERANCE
DECIMAL MULTIPLIER; OR NUMBER OF ZEROS AFTER SIGNIFICANT FIGURES.

Color	Figure or Multiplier	Characteristic Letter	Tolerance	Color	Figure or Multiplier	Characteristic Letter	Tolerance
Black	0	A	20% (M)	Blue	6	....	....
Brown	1	B		Violet	7	....	....
Red	2	C	2% (G)	Gray	8	I	....
Orange	3	D	3% (H)	White	9	J	....
Yellow	4	E	....	Gold	.1	....	....
Green	5	....	5% (J)	Silver	.01	....	10% (K)

RMA REC 115 CHARACTERISTIC LETTERS

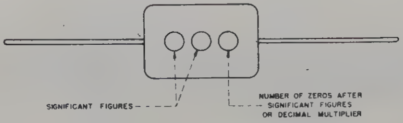
Class	Temperature Coefficient Parts/Million/ Deg. C	Capacitance Drift Not More Than
A	+ —1000	+ —(5% +1 mmf)
B	+ —500	+ —(3% +1 mmf)
C	+ —200	+ —(0.5% +0.5 mmf)
I	+150 — 50	+ —(0.3% +0.2 mmf)
D	+ —100	+ —(0.3% +0.1 mmf)
J	+100 — 50	+ —(0.2% +0.2 mmf)
E	+100 — 20	+ —(0.1% +0.1 mmf)

RMA COLOR CODE

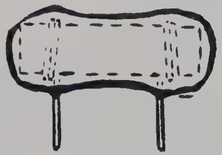
SHEET C19 JUNE 1, 1938

THREE DOT

USED FOR 500 VDCW CAPACITORS WHOSE TOLERANCE IS GREATER THAN 10%


SIGNIFICANT FIGURES
NUMBER OF ZEROS AFTER SIGNIFICANT FIGURES OR DECIMAL MULTIPLIER

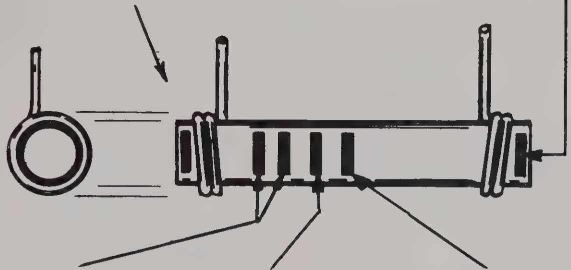
CERAMIC, CAPACITORS



Silver end dot denotes bypass and coupling capacitor.

VOLTAGE

Brown - - 150
Orange - - 350
Omitted - 500



CAPACITY

Black - - - 0
Brown - - - 1
Red - - - - 2
Orange - - 3
Yellow - - 4
Green - - - 5
Blue - - - - 6
Violet - - - 7
Gray - - - - 8
White - - - 9

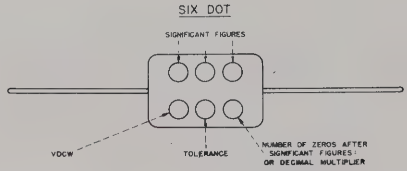
MULTIPLIER

Black - - - 1
Brown - - - 10
Red - - - - 100
Orange - - 1000

TOLERANCE

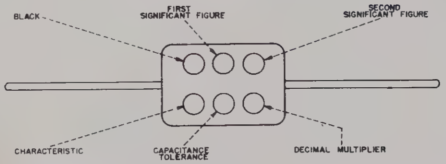
Black - - - ±20%
White - - ±10%
Omitted — Guar. Min. Value

The position of the capacitor illustrates the relation of the leads to the color code. The left end is the termination of the inner electrode.


SIX DOT
SIGNIFICANT FIGURES
VDCW
TOLERANCE
NUMBER OF ZEROS AFTER SIGNIFICANT FIGURES: OR DECIMAL MULTIPLIER

Color	Significant Figure, or No. of Zeros, or Decimal Multiplier	VDCW	Tolerance	Color	Significant Figure, or No. of Zeros, or Decimal Multiplier	VDCW	Tolerance
Black	0	....	....	Violet	7	700	7%
Brown	1	100	1%	Gray	8	800	8%
Red	2	200	2%	White	9	900	9%
Orange	3	300	3%	Gold	.1	1000	....
Yellow	4	400	4%	Silver	.01	2000	10%
Green	5	500	5%	None	....	500	20%
Blue	6	600	6%				

JAN-C-5 COLOR CODE


BLACK
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
CHARACTERISTIC
CAPACITANCE TOLERANCE
DECIMAL MULTIPLIER

Color	Figure or Multiplier	Character-istic Letter	Tolerance	Color	Figure or Multiplier	Character-istic Letter	Tolerance
Black	0	A	20% (M)	Blue	6	G	....
Brown	1	B	....	Violet	7	....	....
Red	2	C	2% (G)	Gray	8	....	....
Orange	3	D	....	White	9	....	....
Yellow	4	E	....	Gold	.1	....	5% (J)
Green	5	F	....	Silver	.01	....	10% (K)

JAN-C-5 CHARACTERISTIC LETTERS

Char-acter-istic	Temperature Coefficient Parts/Million/Deg. C	Maximum Capacitance Drift	Verification of Characteristics By Production Test
A	Not Specified	Not Specified	Not Required
B	Not Specified	Not Specified	Not Required
C	—200 to +200	+— 0.5%	Not Required
D	—100 to +100	+— 0.3%	Not Required
E	—20 to +100	+—(0.1% + 0.1 mmf)	Not Required
F	0 to +70	+—(0.05% + 0.1 mmf)	Required
G	0 to —50	+—(0.05% + 0.1 mmf)	Required

CHASSIS MOUNTING INSTRUCTIONS

Place chassis so that it is as shown in Diagrams 1 & 2. Mount parts in the order described below. MAKE CERTAIN THE DIRECTION OF EACH PART IS AS SHOWN IN DIAGRAM 2.

NOTE: BEND LOCATING TABS DOWN ON ALL POTS.

PALNUTS-

The Palnuts have been incorporated into this unit in order to simplify, speed-up and improve the mechanical assembly. Since this nut is a self locking device, it eliminates the necessity of lockwashers. It is most important that these nuts be placed on properly. The solid (concave) side is the side applied to the screw.

PART	PART#	MOUNT IN HOLE #	WITH		REMARKS
			AM'T	PART#	
7 Pin Min. Molded Socket	H-25	3	2	H-9	
		4	2	H-10	
		5	2	H-11	
7 Pin Min. Wafer Socket	H-8	11	2	H-9	
		12	2	H-10	
		13	2	H-11	
Octal Molded Socket	H-21	17			
		18	2	H-6	
		19	2	H-7	
Octal Wafer Socket	H-4	14			
		15	2	H-6	
		16	2	H-7	
2M Potentiometer	R-11	6	1	H-2	Lockwasher
			1	H-3	under chassis
2K "	R-25	7	1	H-2	" "
			1	H-3	
2K "	R-19	8	1	H-2	" "
			1	H-3	
4 Lug Terminal Strip	H-12	24			
			1	H-6	
			1	H-7	
Transformer	T-1	9			Blk or Yel-Blk
		23	2	H-6	thru hole 21,
			2	H-7	rest thru 20.
			1	H22	Mount Solder lug
					over hole 9
			1	H-41	Mount Cable Clamp
					over hole 23
2K Potentiometer	R-26	10	1	H-2	Lockwasher
			1	H-3	under chassis

NOTE: MAKE CERTAIN H41 DOES NOT SHORT H12#1.

DIAGRAM 1 CHASSIS PRE-ASSEMBLY BOTTOM VIEW

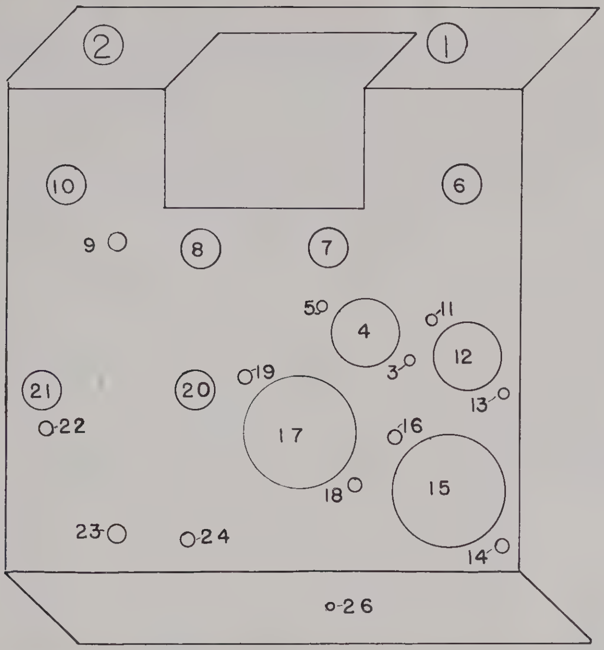
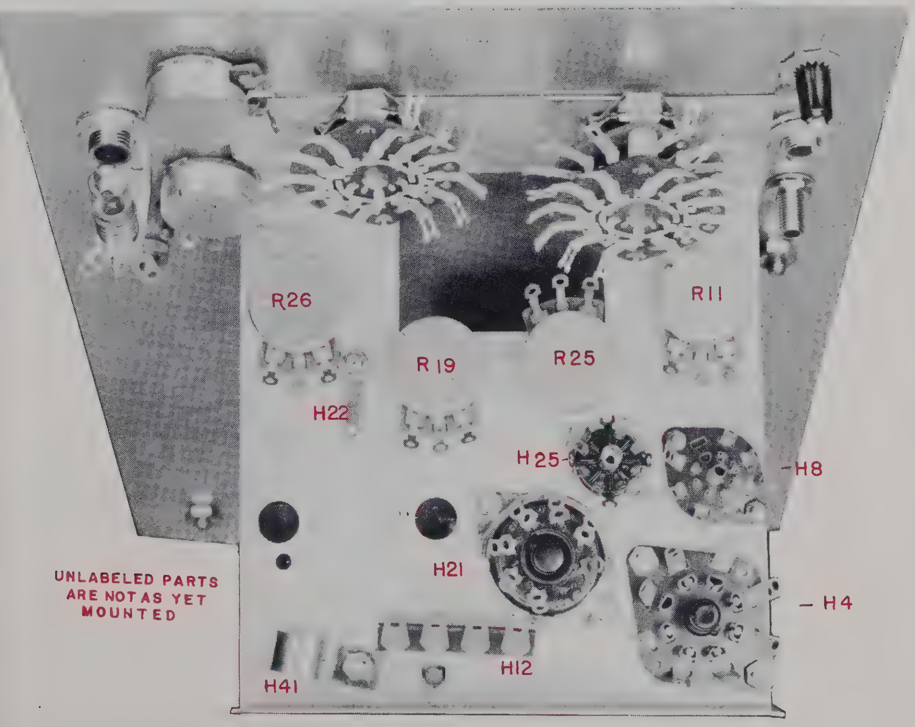

2
1
10
6
9
8
7
5
4
11
12
3
13
21
20
19
17
16
22
15
18
23
24
14
26

DIAGRAM 2 ASSEMBLED CHASSIS BOTTOM VIEW


R26
R11
R19
R25
H22
H25
H8
H21
H4
H41
H12

UNLABELED PARTS
ARE NOT AS YET
MOUNTED

PANEL MOUNTING INSTRUCTIONS

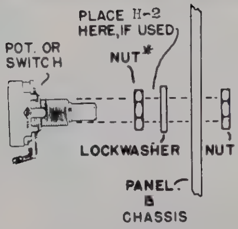
Mount chassis to panel with S1 thru hole #2 of chassis & hole #37 of panel using 1-H2 & 1-H3. H3 next to switch; S2 thru hole #1 of chassis & hole #36 of panel, using 1-H2 & 1-H3. H3 next to switch.

PART	PART #	MOUNT IN HOLE #	WITH AM'T PART#		REMARKS
Chassis Connector	H-13	40	1 1	H-2 H-3	
Banana Jack	H-14	39	1 1	H-15 H-16	
Pilot Light Bracket	B-1	42	1 1	H-18 H-19	
Pin Jack	H-20	41			Press Star Washer onto Pin Jack once on Panel.
2K Potentiometer	R-23	35	1 1	H-2 H-3	See insert
2K Potentiometer	R-20	34	1 1	H-2 H-3	See insert

Mount meter in holes 28, 29, 32 & 33 using 4-#8 lockwashers & 4-brass hex nuts. Mount 2-meter solder lugs on meter terminals using brass flat washers and brass hex nuts.

You have now completed the mounting of all the major components. It is usually advisable to quickly recheck here before wiring.

POTENTIOMETER MOUNTING



* USE EXTRA NUT, WHEN ATTACHING TO PANEL, IF 3/8" LONG BUSHING IS USED ON SWITCHES AND POTENTIOMETERS.

DIAGRAM 3 PANEL PRE-ASSEMBLY REAR VIEW

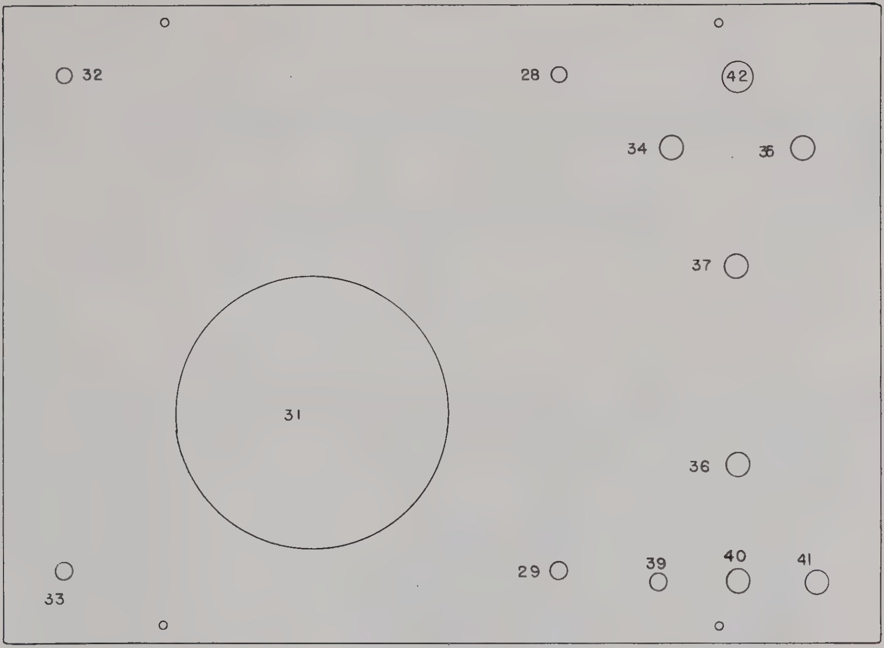
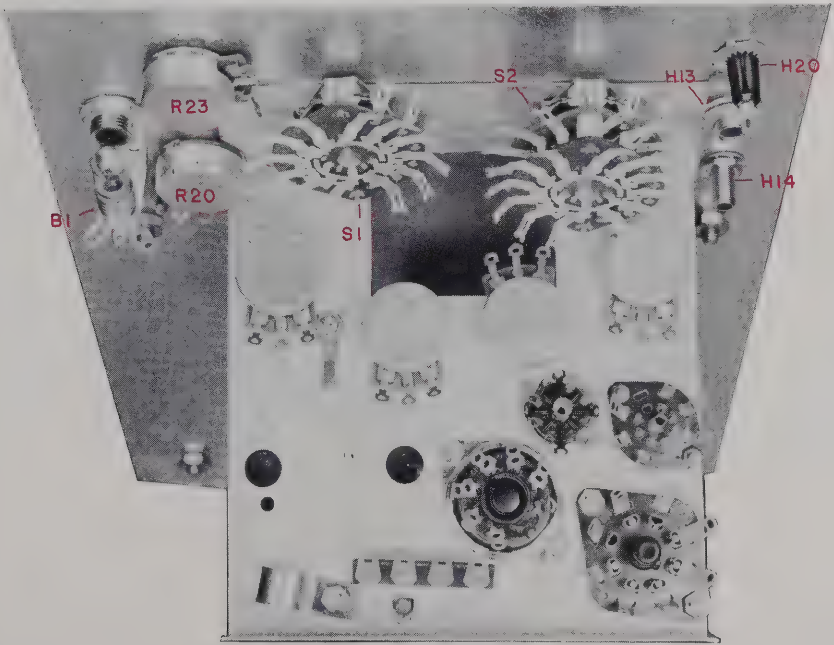

32
28
42
34
35
37
31
36
33
29
39
40
41

DIAGRAM 4 PANEL ASSEMBLY REAR VIEW

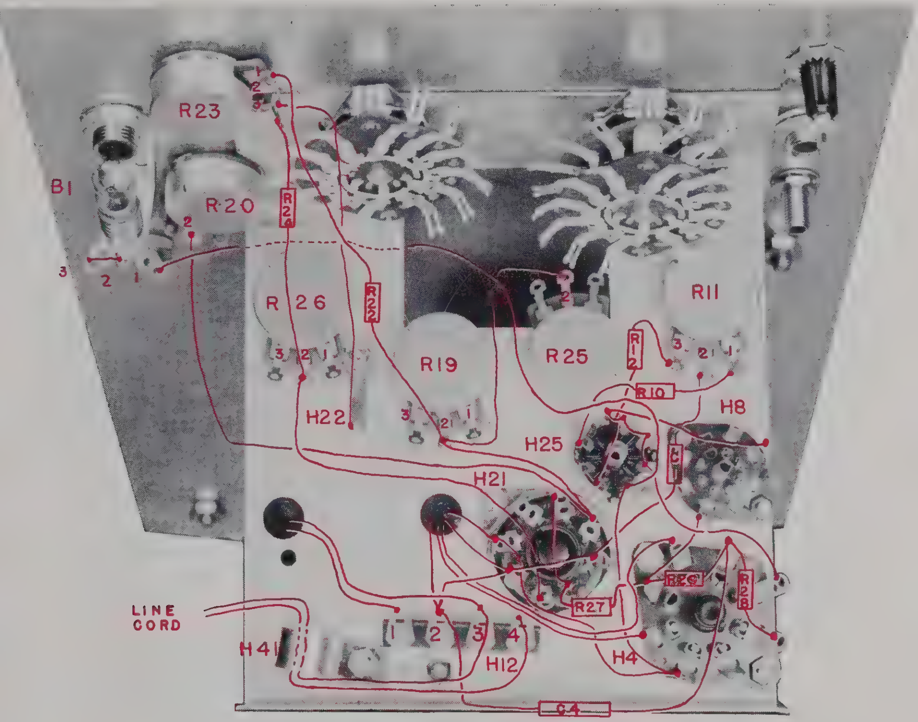

S2
H13
H20
R23
H14
R20
B1
S1

NOTE: * means solder. If no asterisk appears simply connect the wire to that contact and leave it there. It will be soldered later on.
Tube sockets, viewed from the bottom, are numbered clockwise starting from the key.

CHECK	PART	PART#	WIRE FROM	WIRE TO	REMARKS
	Line Cord	W-2		H12#4	Around cable clamp and knot wire
	" "	"		H12#3	Other lead
	Trans.	T-1		H12#3*	Yellow-black or black wire
	"	"		H4#3*	Red wire
	"	"		H4#5*	Other red wire
	"	"		H12#2	Red-yellow wire
	"	"		H12#1	Other yellow-black or black wire
	"	"		H21#8	Yellow wire
	"	"		H21#7	Other yellow wire
	Wire	W-1	H21#7	H21#4	
	"	"	H21#7*	H12#2	
	"	"	H21#8*	H4#2	
	"	"	H4#2*	H25#4	
	"	"	H25#4*	B1#1*	
	"	"	H4#7*	H25#3	
	"	"	H25#3*	H25#2	
	"	"	H25#2*	H25#1	
	"	"	H25#1*	Ground	Ground lug on H-25
	10K Res. 1w	R-28	H4#8*	H4#6	Spaghetti
	4.7K Res. 1w	R-29	H4#6	H4#4	"
	4.7K Res. 1w	R-27	H4#4	H21#5	
	Wire	W-1	B1#2*	B1#3*	
	Wire	W-1	H21#5*	H21#2*	
	Wire	W-1	H4#4*	H8#5*	
	Wire	W-1	H8#2*	Ground	Ground Lug on H-25
	Wire	W-1	R26#2	H21#6*	
	24 ufd Cond.	C-4	H12#2*	H4#6*	Plus side to #6
	Wire	W-1	R25#2*	R19#2	
	"	"	R19#2	H21#3	
	"	"	H21#3*	R20#2	
	470 ohm Res.	R-22	R19#2*	R23#1*	Spaghetti
	" " "	R-24	R23#3*	R26#2	"
	Wire	W-1	R23#2*	H22	
	1.5M Res.	R-10	H25#7*	R11#1*	Spaghetti
	" "	R-12	H25#5	R11#3*	"
	.01 Cond.	C-1	H21#4*	R11#2	"

PURPOSE OF THE CIRCUIT: Is to explain the function of the major components and their location. To those who are not too familiar with the operation of VTVM's, we suggest reading the explanatory section of the instruction book before trying to digest this section. By necessity this must be brief. The first steps, thru condenser C4, represents the filaments and full-wave rectifier power supply. The next wiring, up to the resistors R10 & R12 is part of the connections to the Zero and Calibration potentiometers. These allow each function of the instrument to be separately calibrated and operates by virtue of adjusting the sensitivity of the meter movement for each Function selected. It thereby corrects for meter inaccuracies, variations in tubes, etc.
R10 & R12 serve as limiting and decoupling resistors in the AC rectifier circuit Conceivably they could be omitted, but stability and ease of adjustment would be somewhat reduced.

DIAGRAM 5 CHASSIS WIRING BOTTOM VIEW


R23
1
2
3
B1
R20
2
3
2
1
R24
R22
R 26
3
2
1
R19
3
2
1
H22
R25
R12
R11
3
2
1
R10
H8
H25
H21
C1
R29
R28
R27
LINE CORD
H41
1
2
3
4
H12
H4
C4

FINAL WIRING

CHECK	PART	PART#	WIRE FROM	WIRE TO	REMARKS
	Wire	W-1	S2D#5*	S2D#3	
	"	"	S2D#3*	S2D#2	
	"	"	S2D#2*	S1B#R*	
	5.6M Res.	R-8	S2D#4*	S2B#4	
	8M Res.	R-1	S1A#1	S1A#2	Precision Res. Spaghetti
	1.8M Res.	R-2	S1A#2*	S1A#3	" " "
	100K Res.	R-3	S1A#3*	S1A#4	" " "
	50K Res.	R-4	S1A#4	S1A#5	" " "
	" "	R-5	S1A#5*	H22*	" " "
	10 Ohm Res.	R-16	S1C#1*	Ground	" " " Ground Lug on H21
	100 " "	R-17	S1C#2*	Ground	Precision Res. Spaghetti Ground Lug on H21
	10K Res.	R-18	S1C#3*	Ground	Precision Res. Spaghetti Ground Lug on H21*
	Wire	W-1	S1C#4*	S1A#4*	
	"	"	S1A#R*	S1B#1	
	3.9M Res.	R-13	S1B#1*	S1B#2	Spaghetti
	1.5M Res.	R-14	S1B#2*	S1B#3	"
	100K Res.	R-15	S1B#3*	S1B#4* & #5*	"
	Wire	W-1	S2F#2	S2F#3	
	"	"	S2F#3*	S2F#4	
	"	"	S2F#4*	S2F#5*	
	"	"	S2F#2*	H12#1*	
	"	"	S2E#3*	S2E#4	
	"	"	S2E#4*	S2C#2	
	"	"	S2E#5*	R26#3*	
	"	"	S2C#2*	R26#2*	
	"	"	S2F#R*	H12#4*	
	"	"	S2C#3*	R19#3*	
	"	"	S2C#4*	R20#3*	
	"	"	S2E#2*	R25#1*	
	"	"	S2C#5*	R20#2*	
	Mount Battery into Battery Bracket securing with 1 H-5 & 1 H-6. Place onto hole #22 securing with 1 H-7 & 1 H-6, plus side of Battery toward panel under chassis.				
	Wire	W-1	S2B#4	+ side Battery*	
	.01 Cond.	C-5	S2B#4*	Ground	Ground Lug on H25*
	820K Res.	R-9	S2B#5*	S2A#1	Spaghetti
	.01 Cond.	C-2	S2A#1*	H25#5*	
	Wire	W-1	S2B#R*	AC Jack*	
	"	"	S2A#R*	S1A#1*	
	"	"	S2A#3*	S2A#2	
	"	"	S2A#2*	Chassis Connector	Strip wire ¼" - push thru and solder at center,, cut off surplus.
	Wire	W-1	S2A#5*	R11#2*	
	"	"	S2A#4*	S1C#5*	
	"	"	S2E#R*	Meter Lug*	Meter Lug - nearer to chassis
	Wire	W-1	S2C#R*	Meter Lug*	Meter Lug - further from chassis
	"	"	S1C#R*	Battery*	Negative side
	1.2M Res.	R-21	H21#1*	S2D#R	
	.0015 Cond.	C-3	S2D#R*	Ground	Ground Lug on H21*

DIAGRAM 6 SWITCH NUMBERING SIDE VIEW

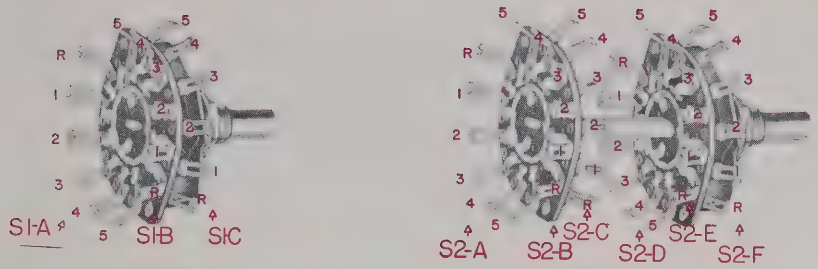
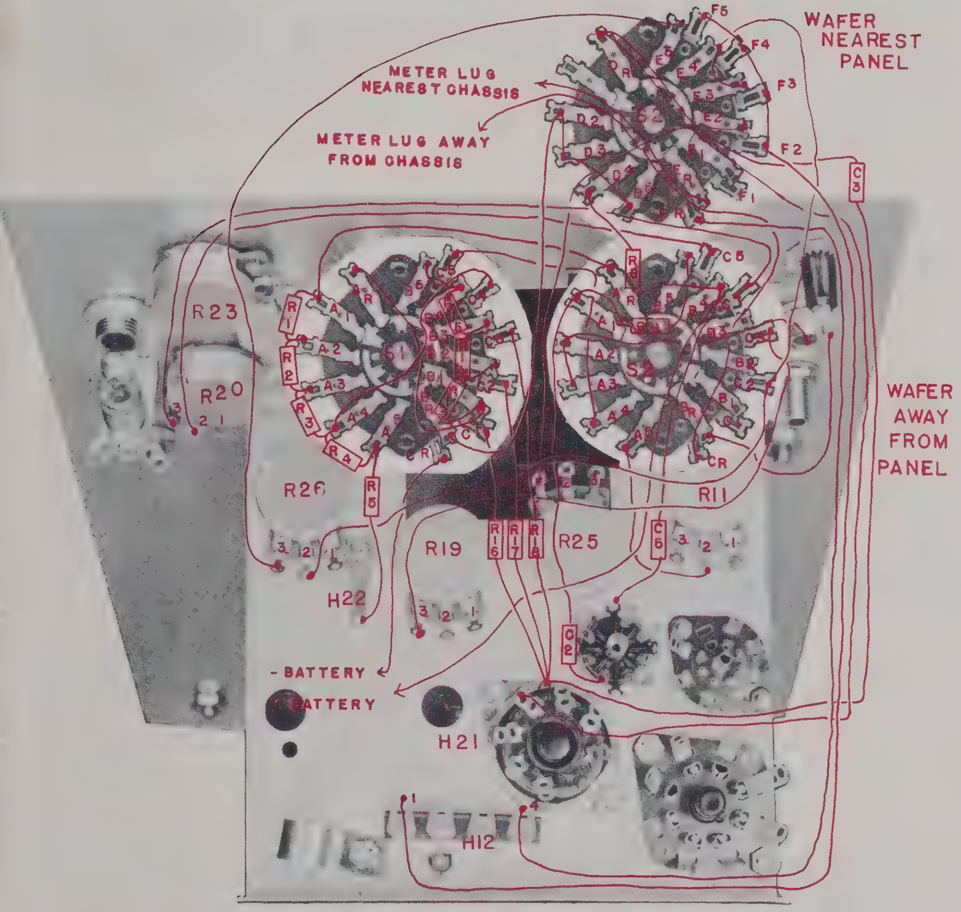

R
1
2
3
4
5
S1-A
S1-B
S1-C
S2-A
S2-B
S2-C
S2-D
S2-E
S2-F

DIAGRAM 7 PANEL & CHASSIS WIRING BOTTOM VIEW


WAFER NEAREST PANEL
METER LUG NEAREST CHASSIS
METER LUG AWAY FROM CHASSIS
S2
F1
F2
F3
F4
F5
C3
S1
R1
R2
R3
R4
R5
R6
R23
R20
R26
R11
R19
R25
R16
R17
R18
C5
C2
H22
H21
H12
WAFER AWAY FROM PANEL
- BATTERY
+ BATTERY

LEAD PREPARATION

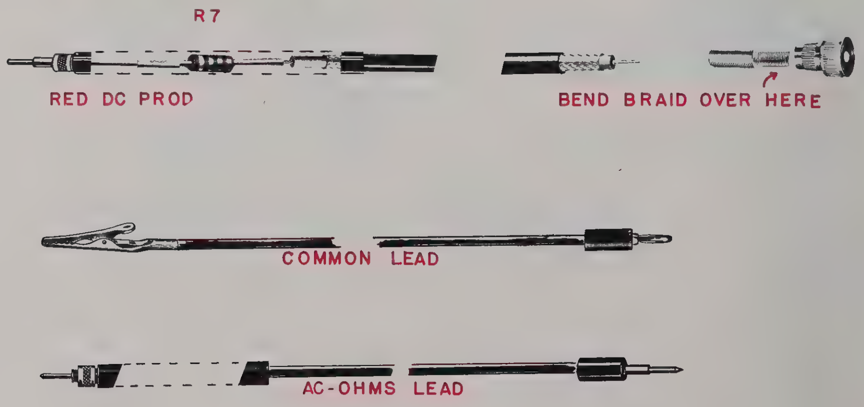
DC PROBE LEAD: Strip the top insulation and shielded braid off about 1 inch from 1 end of the coaxial wire. Remove the inside insulation about ¼" exposing the inner conductor. Solder Resistor R-7 to the exposed wire. Unscrew the small metal sleeve from the tip of the Red Test Prod. Insert the Resistor and Cable into the Red Prod and gradually press in until the wire from R-7 appears in the small hole in the metal tip of the Prod. Pull the lead through as far as it will go, without too much pressure. Clip off until about ¼" of the lead is protruding through the hole. Bend wire around and secure by reattaching metal sleeve to tip.

Strip top insulation of other end of coaxial cable about 1 inch. Do not remove braid. Loosen screw of microphone connector and remove the spring. Slip spring over cable with smaller diameter end toward the stripped portion of cable. Bend braid over as far as it will go over smaller diameter portion of spring. Remove about 5/8 inch of inside insulation, and slip exposed twisted wire through hole in the center of the microphone connector, allowing it to extend through small hole in front of connector. Make certain that all exposed wires come thru at once, since these can cause shorts. Press small spring and braid into mike connector and secure by tightening set screw. Solder wire in front of connector and cut off all excess. Go over the end with carbon tetrachloride to remove rosin.

COMMON LEAD: Clean off about ¼" of wire from each end of one of the black test leads. Solder one end to alligator clip. Remove the black plastic cover from the banana plug and slip it over the other end of the wire. Solder wire to brass plug on banana plug and screw insulator back on.

AC LEAD: Remove the small metal sleeve from one end of the black test prod. Strip about ¼" from each side of test lead wire and thread wire through prod until it extends through the hole in the metal tip. Bend wire around tip and secure by reconnecting the metal sleeve. Remove the black plastic cover of the pin plug, and slip it over the other end of the wire. Solder exposed wire of test lead to the top of the plug. Screw black cover back on.

DIAGRAM 8 LEADS



PRELIMINARY MECHANICAL ASSEMBLY:

You have now completed the wiring of your instrument. Before proceeding, carefully recheck all connections for the possibility of shorts between wires, unsoldered terminals, loose solder particles, rosin between lugs and shorted contacts. Make certain that all nuts are tight. Secure knobs to switch, and potentiometer shafts on the front panel. When aligning knobs, both switches should be in their maximum counter-clockwise position. The knob pointer should be in the 'OFF' position of the FUNCTION switch, and in the '5V' position of the SELECTOR switch. Insert tubes in sockets as indicated in diagram 9. Temporarily connect meter lugs to meter terminals. Do not mount instrument in cabinet as yet. Lug from S2E R connects to the right terminal of the meter (as viewed from rear) and lug from S2C R connects to the left terminal.

ELECTRICAL TEST:

If an ohmmeter is available, connect it between 8 of the 6X5 and ground. The reading should be at least 50,000 ohms. If less, recheck circuit carefully before inserting line cord. Adjust the mechanical Zero Adjust (located in the center of the meter case) to zero, on the left side of the scale, before power is turned on.

ELECTRICAL CALIBRATION:

Insert each one of the test leads tightly into their proper jacks. Insert line cord and turn power on by rotating the FUNCTION selector to the -DC position. Turn the SELECTOR switch to the '5V' position. Note: The pilot light and tubes should light immediately. If they do not, turn power off and recheck circuit for the possibility of a short or open circuit. Allow set an initial warm-up period of about a half hour.

-DC CALIBRATION: Short the COMMON and DC PROBE leads together; adjust the ZERO ADJUST potentiometer for a zero reading on the left side of the meter scale. On low voltage ranges, a change in zero setting may be observed when the leads are unshorted. This should not be of concern as it is due to the extreme sensitivity of the meter. Connect three 1½ volt batteries in series, thus giving an open circuit voltage of 4.68 volts. (The open circuit voltage of a flashlight battery is 1.56 volts.) Connect the COMMON lead to the plus side of the batteries and the DC PROBE lead to the negative side. Adjust the -DC CALIBRATION potentiometer (located on the chassis) for 4.68 volts on the top DC scale of the meter. See Diagram 9.

+DC CALIBRATION: Repeat as in -DC CALIBRATION except that the FUNCTION switch is rotated to the +DC position; the leads to the battery are reversed and the +DC CALIBRATION potentiometer is adjusted.

OHMS CALIBRATION: The ohmmeter is automatically calibrated and it operates as indicated in the following instruction book.

AC CALIBRATION: Rotate the FUNCTION switch to the AC VOLTS and the SELECTOR switch to the '5' range. Short the AC and COMMON leads together and adjust the AC ZERO potentiometer (located on chassis) for a zero reading on the left side of the meter scale. A standard AC meter should actually be used during this calibration. But for accuracies as normally encountered, the following may be used: rotate the SELECTOR switch to the 250 volt range and connect the COMMON lead to one side of the 110 volt AC power line and the AC-OHMS lead to the other side. (Note: Since the COMMON lead is connected to the panel of the meter, and this lead is being connected to one

AC CALIBRATION (cont'd)

side of the AC line, be very careful not to ground yourself during this adjustment. Use one hand and make sure you are standing on a dry surface). Adjust the AC CALIBRATION potentiometer for 110 volts on the 250 volt range (near center reading).

FINAL CALIBRATION: Vacuum tubes have what is technically called an 'aging characteristic'. The tube ages rapidly at the first and then tapers off to a balanced or equilibrium condition. Before aging has taken place, the meter may have a tendency to lose its zero adjust or readings may be a bit non-linear. A true calibration occurs after the tubes have been used over a period of a few months. It is suggested, therefore, that a final calibration be made several months after the instrument has been in use. At that time the CALIBRATION and ZERO potentiometers should be re-adjusted and finally sealed by sealing wax or a touch of varnish between the shaft and screw assembly.

MOUNTING HANDLE:

Secure the handle to the cabinet by using the handle brackets, screws and palnuts.

MOUNTING PANEL AND CHASSIS TO CABINET:

Thread line cord through hole in rear of cabinet. Slide set into cabinet and secure by means of a self-tapping screw at the rear of the chassis. Secure panel to cabinet by using 4 self-tapping screws. Note: Attach screws, but do not tighten until all have been started. Be very careful to use a large screw driver which will not slip. If screws thread at an angle, they will straighten as the screw is tightened.

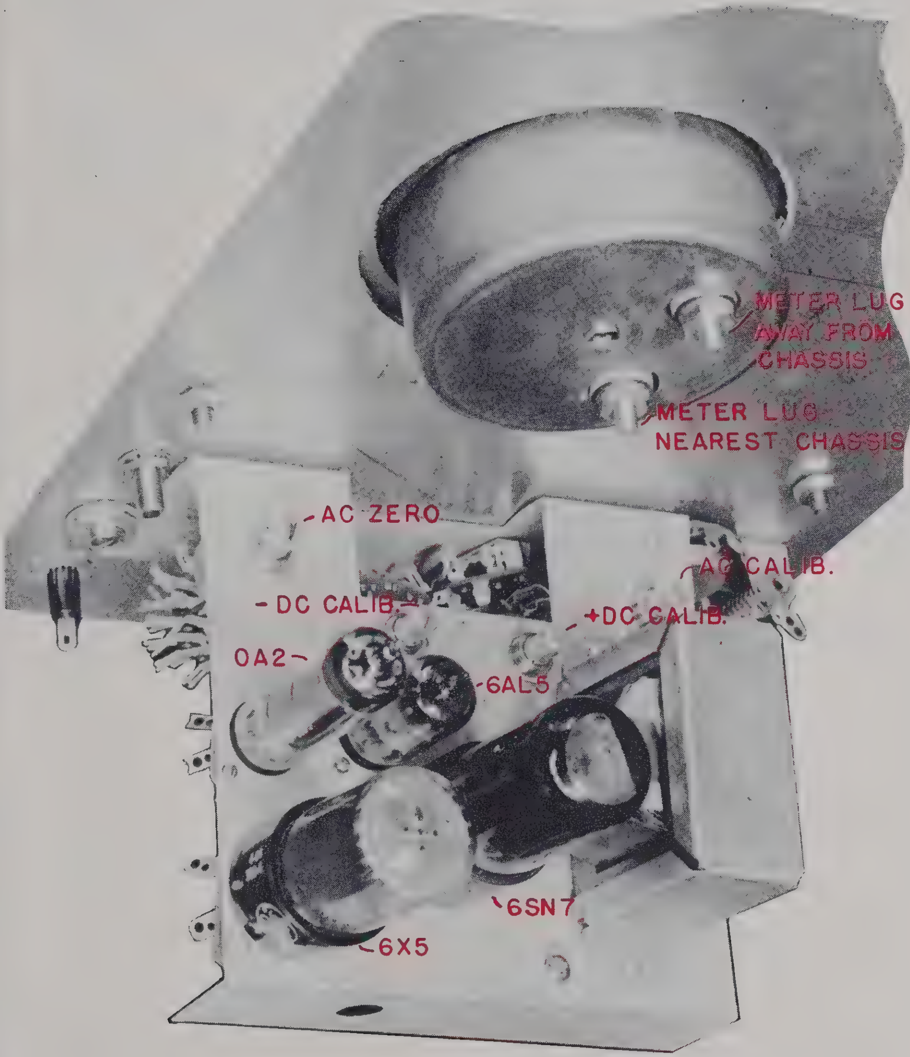
SERVICING:

In the event of difficulty recheck the wiring carefully. Most troubles may be immediately traced to wiring mistakes, rosin joints, rosin between contacts or shorts.

FACTORY REPAIR:

If a question should arise, write to our Engineering Department listing all possible readings, etc. which may aid in analyzing the problem. Your letter will be answered promptly. Your instrument may, if you so desire, be returned to the factory for final repair and calibration at a service charge of $5.50. This does not include the cost of parts that may have been damaged due to misuse. BE SURE TO INCLUDE TEST LEADS IF YOU RETURN YOUR UNIT FOR FACTORY CALIBRATION. If the instrument is to be returned to us, pack carefully in at least two cartons insulated by paper or excelsior between them. Ship EXPRESS PREPAID. We do not suggest the use of MAIL. The instrument will be returned to you EXPRESS COLLECT. Please make certain that all parts are secured tightly in place so that vibration during transit will not cause damage.

DIAGRAM 9 COMPLETE ASSEMBLY REAR VIEW


METER LUG AWAY FROM CHASSIS
METER LUG NEAREST CHASSIS
AC ZERO
AC CALIB.
- DC CALIB.
+DC CALIB.
OA2
6AL5
6SN7
6X5

ADDENDA

In order to maintain your instrument in its most modern form, certain improvements are made from time to time. These will be noted in the following space. If none are listed, no changes are immediately contemplated. If changes are listed, correct the wiring, etc. in the construction book before proceeding with the actual construction.

COMMONLY USED RADIO FORMULAS

$R = \frac{E}{I}$ $E = IR$ $I = \frac{E}{R}$

$Z = \frac{E}{I}$ $E = IZ$ $I = \frac{E}{Z}$

$X_C = \frac{1}{2\pi f C}$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$Z = R + j(X_L - X_C)$

$X_L = 2\pi f L$

$f = 1/2\pi\sqrt{LC}$ at resonance

Z of inductive — resistive circuit(magnitude) $= (R^2 + X_L^2)^{\frac{1}{2}}$

" " capacitive & " " " $= (R^2 + X_C^2)^{\frac{1}{2}}$

Approximate Pentode Amplifier Gain $= g_m Z_L$

" Triode " " $= uR_L/(R_p + R_L)$

" Cathode Follower Z $= 1/g_m$

R - ohms

E - volts

I - Amperes

X_C - Capacitive Reactance

X_L - Inductive Reactance

Z - AC Impedance

C - Capacitance

L - Inductance

j - Operator

g_m - Plate transconductance

Z_L - Plate Load Z

R_L - Plate Load R

R_p - Plate R

u - Amplification Factor

GENERAL DESCRIPTION

Your Model 9071 Vacuum Tube Voltmeter is another example of 'an engineered product' by PRECISE.

This instrument was initially designed to permit rapid and accurate measurements in electronic circuits. It is flexible both electrically and mechanically.

Each component, from the Amphenol connector on the front panel to the Precision CERAMIC and WIREWOUND resistors used internally, was carefully selected for accuracy and durability. The circuit has been time-tested and proved; thereby, assuring the operator of quality and stability.

SPECIFICATIONS:

Electrical:	Power	11 watts
	Voltage	105-125 volts
	Line Frequency	60 cycles
	DC Impedance	25 Megohms
	AC Impedance	3.5 Megohms (approx.)
	Battery	1.5 volts (flashlight)
	Ranges	DC from .1 to 1,000 volts AC from .25 to 1,000 volts Ohms from .2 to 1,000,000,000 DB from -20 to +55 db
	Tubes	1 - 6AL5 1 - 6SN7 1 - 6X5 1 - OA2
Mechanical:	Height	8 inches
	Width	11 inches
	Depth	5 inches
	Weight	10 pounds
	Panel	Slate grey, etched, raised numerals, aluminum
	Cabinet	Steel, wrinkle grey, baked finish
	Handle	Genuine leather
	Meter	7½ inches square

OPERATION

POWER ON: Insert the line cord and rotate the FUNCTION switch to any position, other than the POWER OFF. This will automatically turn on the instrument. Always allow an initial 'warm-up' period before any adjustments are made.

DC VOLTAGE MEASUREMENTS:

(1) All DC measurements are made with the Red DC VOLTS test prod and the COMMON alligator lead.

(2) Rotate the FUNCTION switch to - or +DC, as required.

(3) Rotate the SELECTOR switch to the voltage range required.

(4) Short the COMMON and DC VOLTS leads together and adjust the ZERO ADJUST for '0' on the left side of the meter scale. Note: There may be a tendency for the meter to go off it's zero position when the leads are no longer shorted. This is due to the high sensitivity of the instrument and should be of little concern, since it will still read correctly when connected across a circuit.

(5) Connect the COMMON and DC VOLTS leads to the circuit being measured. Note: The COMMON lead is usually clipped to the ground side.

(6) All DC voltage measurements are then read on the lower portion of the top meter scale.

AC VOLTAGE MEASUREMENTS:

(1) All AC voltage measurements are made with the Black OHMS-AC test prod and the COMMON alligator clip.

(2) Rotate the FUNCTION switch to the AC-VOLTS position.

(3) Rotate the SELECTOR switch to the voltage range required.

(4) Short the COMMON and AC leads together and adjust the ZERO ADJUST for '0' on the left side of the meter scale.

(5) All AC measurements, except those of the 5 Volt range, are read on the lower portion of the top meter scale, marked A.C. When the 5 Volt range is used, measurements are read on the 5 VOLTS A.C. ONLY scale of the meter.

RESISTANCE MEASUREMENTS:

(1) All resistance measurements are made with the OHMS-AC and COMMON leads.

(2) Rotate the FUNCTION switch to the OHMS position.

(3) Rotate the SELECTOR switch to the resistance multiplier desired

RESISTANCE MEASUREMENTS (cont'd):

(4) Short the OHMS and COMMON leads together and adjust the ZERO ADJUST knob for '0' on the top of the meter scale.

(5) Remove the short across the test leads and adjust the OHMS ADJUST knob for '∞' on the OHMS scale.

(6) Place the test leads across the part to be measured and multiply the reading on the OHMS meter scale by the multiplier shown on the SELECTOR switch. Caution: Whenever OHMS measurements are being made, make certain that no voltage is applied to the part being tested.

DECIBLES:

(1) Proceed as described in AC VOLTS except for the following:
  (a) All measurements are made on the DB meter scale.
  (b) For each AC setting on the SELECTOR switch, the following chart should be used for determining the number of DB to be added to that read:

AC RANGE	ADD THE FOLLOWING DB
25	+0
250	+20
500	+26
1000	+32

As an example: If the meter read +21 db and the 250 volt range were used- the true reading would be: +21 +20 = +41 db. The 5 VOLT AC Range is not used on DB measurements.

FM ALIGNMENT SCALE:

(1) Proceed as in DC, except that the meter is ZERO ADJUSTED to the '0' shown on the bottom of the scale. Note: Use the +DC range on the FUNCTION switch, if the -DC range is used the polarities indicated on the scale are reversed.

CIRCUIT DESCRIPTION

DC CIRCUIT:

In the DC position of the FUNCTION switch, the DC voltage being measured is directed as follows:

(1) The voltage is applied to the DC lead.

(2) The FUNCTION DECADE, composed of Precision Resistors, drops the voltage to the proper ratio.

(3) The output voltage is applied to the CATHODE-FOLLOWER DC AMPLIFIER and then to one side of the DC meter.

(4) The BALANCE BRIDGE AMPLIFIER is connected to the other side of the meter and, by bridge action, stabilizes and insures reading accuracy.

DC CIRCUIT (cont'd):

(5) The -DC and +DC CALIBRATION POTENTIOMETERS adjust the meter to the proper reading by setting the upper portion of the scale- the lower portion was set by the ZERO ADJUST.

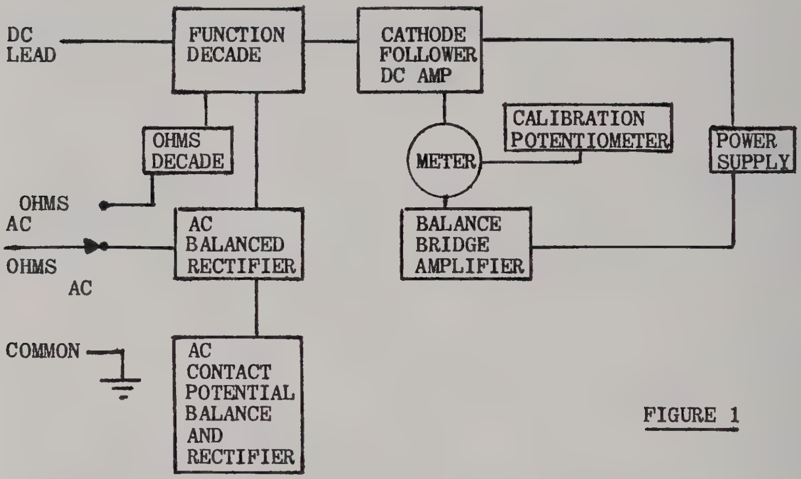

DC LEAD
FUNCTION DECADE
CATHODE FOLLOWER DC AMP
CALIBRATION POTENTIOMETER
POWER SUPPLY
OHMS DECADE
METER
OHMS
AC
OHMS
AC
AC BALANCED RECTIFIER
BALANCE BRIDGE AMPLIFIER
COMMON
AC CONTACT POTENTIAL BALANCE AND RECTIFIER

FIGURE 1

AC CIRCUIT:

(1) In the AC position of the FUNCTION switch, the AC voltage follows a similar pattern to that shown in DC, except that it is sent to the AC BALANCED RECTIFIER where it is connected to the DC circuit. The contact potential is balanced in order to keep Zero Adjust and to maintain accuracy.

DB CIRCUIT:

(1) The DB circuit operates in the same manner as that described under AC CIRCUIT.

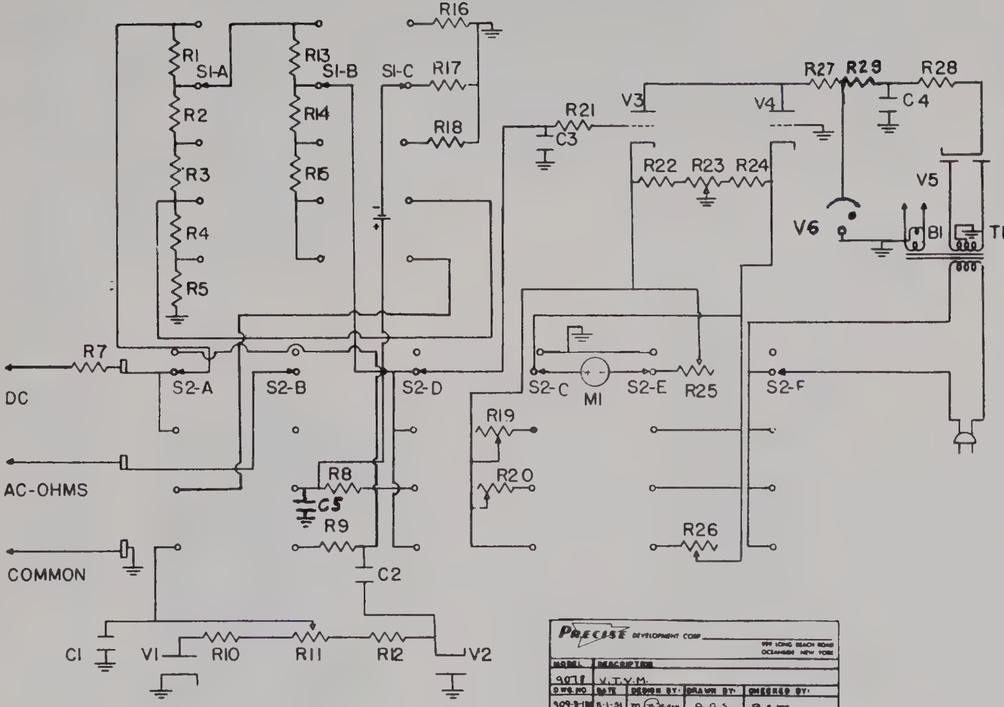
OHMS CIRCUIT:

(1) In the OHMS Circuit the battery voltage is applied to the Precision Ceramic resistors of the OHM'S decade. The series voltage drop across the unknown resistance is then measured by the CATHODE FOLLOWER DC AMPLIFIER as described under DC VOLTS.

WARRANTY

All merchandise is warranted to be free from defects in material and workmanship, and is fully protected by the standard RMA guarantee.

9071 VTVM


R16
R1
S1-A
R13
S1-B
S1-C
R17
R18
R2
R14
R3
R15
R4
R5
R21
C3
V3
V4
R27
R29
R28
C4
R22
R23
R24
V5
V6
B1
T1
R7
DC
S2-A
S2-B
S2-D
S2-C
M1
S2-E
R25
S2-F
R19
R20
AC-OHMS
R8
C5
R9
R26
COMMON
C2
C1
V1
R10
R11
R12
V2

PRECISE DEVELOPMENT CORP.
[illegible] LONG BEACH ROAD
OCEANSIDE NEW YORK

MODEL	DESCRIPTION			
9071	V.T.V.M.			
DWG. NO.	DATE	DESIGN BY:	DRAWN BY:	CHECKED BY:
909-8-1M	8-1-51	M. [illegible]	A.B.S.	B.[illegible]

REVISIONS:

SUPERCEDES DWG. NO.

DESCRIPTION	PART #
8M ohm Res.*	R-1
1.8M ohm Res.*	R-2
.1M " " *	R-3
50K " " *	R-4, R-5
15M " "	R-7
5.6M Res.	R-8
820K ohm Res.	R-9
1.5M " "	R-10
2M ohm potentiometer	R-11
1.5M ohm Res.	R-12
3.9M " "	R-13
1.5M " "	R-14
100K " "	R-15
10 ohm Res.*	R-16
100 " " *	R-17
10K " " *	R-18
2K ohm potentiometer	R-19
" " " "	R-20
1.2M ohm Res.	R-21
470 " "	R-22
2K ohm potentiometer	R-23
470 ohm Res.	R-24
2K ohm potentiometer	R-25
" " " "	R-26
4.7K ohm Res., 1 watt	R-27
10K ohm Res., 1 watt	R-28
4.7K ohm Res., 1 watt	R-29
3 Pole-5p Switch (1 wafer)	S-1
6 Pole-5p Switch (2 wafer)	S-2
Power Transformer	T-1
6AL5 Tube	V1, V2
6SN7 "	V3, V4
6X5 "	V-5
0A2 "	V-6
.01 ufd Cond.	C-1, C-2, C-5
.0015 ufd Cond.	C-3
24 ufd Cond.	C-4

precise

NEW PRECISE MODEL 111 . . . TUBE TESTER. The latest in Tube Tester design—the NEW 111 is the ONLY KIT that checks BOTH EMISSION and MUTUAL CONDUCTANCE. Features NEW TYPE switches; VOLTAGE SAPPER CHECK; GAS CHECK; simplified SHORT CHECK; LATEST TYPE ROLL CHART; checks all tubes including hearing aid, miniatures, and CRT's.

Rugged construction; deeply etched aluminum panel; 3 color step-by-step construction book. Wt.: 30 lbs. Size: 14″ x 16″ x 6″.

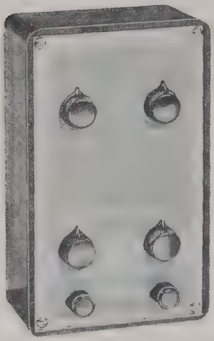
111K . . . . kit form **$69.95**
111W . . . factory wired $139.95

NEW PRECISE MODEL 9071 . . . VACUUM TUBE VOLTMETER WITH VR. PRECISE again the leader—featuring the FIRST VTVM with TRUE VOLTAGE REGULATION. NEW TYPE VR TUBE assures true, accurate and stable readings . . . no drift . . . no shift . . . large, rugged 7½″ meter; separate 5V AC scale; 25 MEG. input on DC; true zero center; deeply etched aluminum panel; sturdy steel case; step-by-step 3 color construction book. Wt.: 11 lbs. Size: 11″ x 8″ x 5″.

9071K . . . . kit form **$35.95**
9071W . . . factory wired $49.95

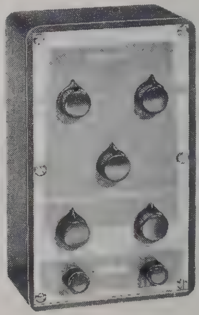
PRECISE NEW MODEL #468 — RESISTANCE DECADE BOX . . PRECISE AGAIN LEADS THE FIELD with its New Low-Priced Resistance Decade Box. Ideal for specialized service work. Compact in size for Bench Drawers and Tool Boxes. Engineered with the customary Precise Accuracy and Dependability.
5 Separate Switches, 11 Positions on Each; plus or minus better than 1% for Extreme Accuracy; Readings from 10 OHM to 1,111,110 OHM in 5 Decades. Deeply etched Aluminum Panel; Rugged Construction; Complete with famous Precise Simplified Construction Manual. 3¾″ x 6¼″ x 2″.

468K.............................kit form.......... . ... **$18.95**
468W.............................factory wired...................................$24.95



NEW PRECISE MODEL 478 . . . CAPACITY DECADE BOX. Over 10 times the Capacity range in the NEW PRECISE CAPACITY DECADE BOX. The first to reach over 1 MFD at 1% accuracy. FOUR DECADES. All capacitors are within 1%; Silver Mica and low-drift, molded, oil-impregnated. Deeply etched aluminum panel; rugged construction; complete with Simplified Construction Manual. Size: 3¾″ x 6¼″ x 2″.

478K . . . kit form **$18.95**
478W . . . factory wired $24.95



NEW PRECISE MODEL 760 . . . VOLTAGE REGULATED POWER SUPPLY. Compact versatility; a must for every serviceman, ham, and lab man. 140 volts to over 450 volts with 1% accuracy. Measures current, high voltage, high and low AC voltage. Rugged 4½″ meter; heavy duty steel case. 3 color construction book. Wt.: 10 lbs. Size: 11″ x 8″ x 5″.

760K . . . . kit form **$39.95**
760W . . . factory wired $59.95

MODEL 635 UNIVERSAL AF SINE, SQUARE AND PULSE GENERATOR. For accurate testing audio and video circuits. 1% Ceramic precision resistors; Wien Bridge; variable Z and cathode-follower output; minimum overshoot and roundoff through 100,000 cycles; sine waves through 200 KC

Model 635K)
Model 635W ....**$52.50** (Factory wired) **$33.50**

precise DEVELOPMENT CORP.

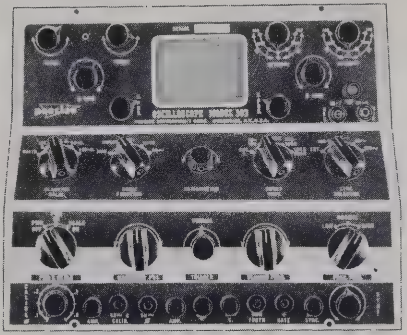
OCEANSIDE, NEW YORK

R.F. SIGNAL GENERATOR

MODEL 610 RF SIGNAL GENERATOR. The lowest priced signal generator in the field offering:—Same RF head as Model 630; 110 MC on fundamentals; 330 MC on harmonics; 60 and 400 cycle AF; Cathode-follower output; Ext. Mod.; Speech Amp.; Individually tuned coils.

Model 610KA . . . $28.95 (pre-assembled head)
Model 610W . . . $39.95 (wired)

Model 610K $23.95



NEW PRECISE MODEL 303 . . . 3″ PORTABLE OSCILLOSCOPE. PRECISE now offers COMPLETE PORTABILITY in the new 3″ scope. NEW 3″ CRT; DC through 5MC ±1½ db; SYNCHRONIZATION FREQUENCY CONTROL, Low, Normal, High, position eliminates horizontal jitters; Internal Square Wave Calibrator and Potentiometer; VOLTAGE REGULATED; Internal Square Wave Calibrator. Deeply etched aluminum panel; Heavy Duty Construction; complete with 3 color step-by-step construction book. Wt.: 14 lbs.

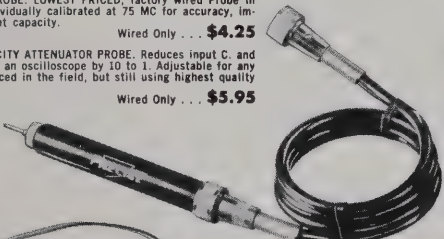
303K . . . . . kit form
303W . . . factory wired

MODEL 912 RF PROBE. LOWEST PRICED, factory wired Probe in the industry. Individually calibrated at 75 MC for accuracy, impedance and shunt capacity.

Wired Only . . . **$4.25**

MODEL 960 CAPACITY ATTENUATOR PROBE. Reduces input C. and loading effects of an oscilloscope by 10 to 1. Adjustable for any scope. Lowest priced in the field, but still using highest quality components.

Wired Only . . . **$5.95**



MODEL 630 RF-AF-TV AND MARKER GENERATOR. For the first time in the history of the industry . . . SO MUCH FOR SO LITTLE. 110 MC on fundamentals, 330 MC on harmonics; Pre-tuned RF (within 1%) head*; AF from 20 to 20,000 cycles; variable % and Ext. Mod.; Cathode-Follower and Constant Z output; Stepping attenuator; Speech Amp.; Xtal Marker with Amp. control; RF and AF Standby; Wien Bridge AF; Colpitts RF; illuminated Drum Dials; Coax outputs; Separately tuned coils; Filtered AC; Vernier tuning; Separate RF; Shielded; 8″ x 11″ x 5″; Etched panel.

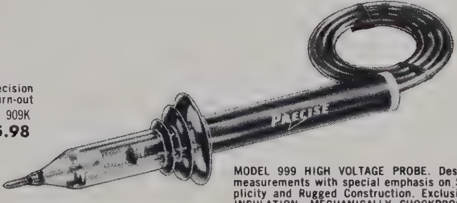
Model 630KA . . . $38.95 (pre-assembled head)
Model 630W . . . $53.95 (Factory wired)

Model 630K $33.95

MODEL 909 VACUUM TUBE VOLTMETER. 1% Ceramic precision Resistors; Coax DC connector; FM zero alignment scale; burn-out proof circuit. Rugged oversize 4½″ meter

Model 909W .... **$37.50** (Factory wired)

Model 909K $25.98



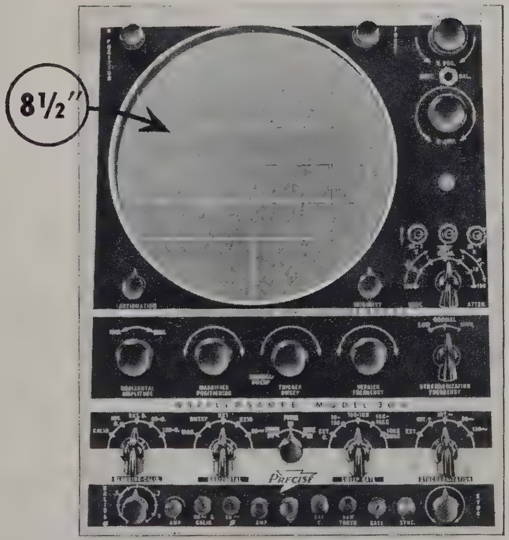
MODEL 999 HIGH VOLTAGE PROBE. Designed for high voltage measurements with special emphasis on Safety, Operational Simplicity and Rugged Construction. Exclusive Features: MULTIPLE INSULATION, MECHANICALLY SHOCKPROOF; CHANGEABLE TIPS; SWIVEL connection. Odds are billions of billions to 1 that no breakdown will occur! INTERCHANGEABLE RESISTORS . . . Wired Only **$6.98**

THERE ARE OTHER PRECISE KITS
PLEASE SEND FOR COMPLETE CATALOG

Prices slightly higher in the West. Prices and specifications subject to change without notice.

THE FASTEST-GROWING KIT MANUFACTURER IN THE WORLD

OSCILLOSCOPES



PRECISE 8½″ OSCILLOSCOPE MODEL #308 . . . BIG SCREEN SCOPE. An oscilloscope unique in the industry . . . THE ONLY 8½″ scope on the commercial market . . . All the general specifications of the time proven Precise model #300; over 72 sq. inches of viewing space provided by its 8½″ tube; ANODE INTENSIFIER; AND FREQUENCY SYNCHRONIZATION CONTROL TO ELIMINATE HORIZONTAL JITTERS (this and other features not found in other scopes at even greater cost) PLUS FULL VOLTAGE REGULATION. Wt.: 35 lbs. Size: 11″ x 14″ x 19″.

308K . .... kit form **$129.50**

308W . . . factory wired **$229.50**

SPECIFICATIONS: PRECISE MODEL 300 OSCILLOSCOPE —

VERTICAL—Vertical-flat (3db) DC through 5 megacycles with sensitivity of greater than 10 millivolts push-pull (3.94 Millivolts/cm); Constant Resistance; Push-pull input immediately converted to single-ended normal or reverse phase by shorting bar at inputs 1 and 2; Frequency compensated vertical stepping attenuator selects AC or DC inputs; Push-pull DC amplifiers from input through output; Internal electronic mixing through inputs 1 and 2; five-way binding posts.

POSITIONING — Bridge type positioning on vertical and horizontal does not vary tube characteristics.

HORIZONTAL — Frequency compensated stepping attenuator in horizontal amplifier; Push-pull Horizontal out.

BLANKING — Internal (return trace blanked), external (return trace not blanked), 60 cycle or 120 cycle Blanking through Blanking amplifier circuit.

SYNCHRONIZATION — External, Internal Positive, Internal Negative, Internal 60 cycle or Internal 120 cycle synchronization.

SWEEP RATE — Driven or non-driven linear sweeps from 1 cycle to 80KC in five ranges (1-10 cycles uses external C circuit); Trigger potentiometer.

MAGNIFIER — Electronic magnifier and magnifier positioner allows any part of a signal to be magnified up to ten times (equivalent to 70 inches of horizontal deflection).

CALIBRATION — Internal square wave calibrator and potentiometer for using oscilloscope at a VTVM on Peak to Peak measurements.

CALIBRATION SCREEN — Edge-illuminated scale and graticule may be turned on or off; filtered screen.

OUTPUTS ON FRONT PANEL — Plus Gate output; Sawtooth output; 60 cycle phasing output; 60 cycle unphased output; Calibration output.

FOCUSING — Astigmatism, focus and intensity control.

CRT — NEW 7″ Tube, normally supplied is medium persistency type 7VP1, or 7JP1 may also be used (oscilloscope green trace) — high persistency types available at additional cost.

DIRECT — Deflection plates available from rear of cabinet.

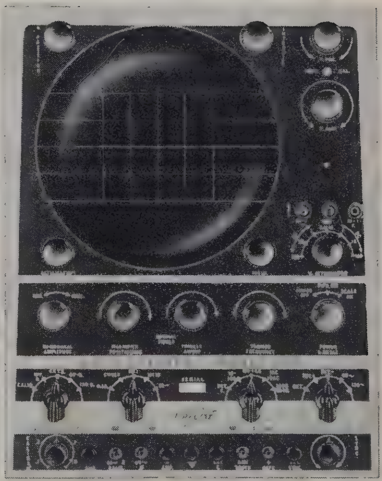
INTENSITY MODULATION — Z modulation through modulation amplifier.

GENERAL — Low loss components; Over-designed fused power supply for additional circuitry; Deeply etched aluminum panel; New parts from original manufacturers — (NO SURPLUS); Steel cabinet; 11″ x 14″ x 17″; complete with instruction book and all components; Accessories: Model 912T(MM) Demodulator Probe and Model 960 Capacity Attenuator Probe available at extra cost — please see specifications on following pages.

There are many additional features and circuits in kit form, which may be added to the Model 300. Please write us for descriptive literature.

300K—kit form **$94.95**

300W—factory wired **$199.50**



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OCEANSIDE, NEW YORK

LITHO IN U.S.A.

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BATTERY TESTER

Built from kit 2/20/84

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GOOD
REPLACE
GOOD
RS
1.5V
9V
6V
7V-8.4V-9V
12V
CORD
ArcherKit
BATTERY TESTER

Catalog Number 28-4020

CUSTOM MANUFACTURED FOR
RADIO SHACK A DIVISION OF TANDY CORPORATION

This ArcherKit Battery Tester is ‘‘pocket-sized’’ but has the testing capability of a full-sized ‘‘bench’’ Tester. It’s simple to build — and you’ll soon have a practical tester that you will be using every day.

To build it you’ll need a pair of wire cutters, a pair of ‘‘long nose’’ pliers, a small Phillips screw driver and a pencil-tip soldering iron. Your Radio Shack store has a nice selection of appropriate size tools for kit building.

The key to good kit operation is good soldering. The information presented on the facing page will give you instructions on how to make good connections. If you have never soldered before, we urge you to study this information and then practice a little before starting to work on your Tester.

Before starting construction, check your parts against the Parts List to be sure you have all the parts. It also will give you a chance to become familiar with the parts before using them.

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THIS KIT MUST BE PROPERLY SOLDERED

USE ENOUGH HEAT

This is the main idea of good soldering. Apply enough heat to the metal surfaces you are joining to make the solder spread freely.

You are not using enough heat if the solder barely melts and forms a rounded ball of rough, flaky solder.

Use the Right Soldering Tool

A soldering iron in the 20-30 watt range is recommended. Any iron in this range with a clean pencil-type tip will supply the correct amount of heat to make a good solder connection.

Keep the iron tip brightly coated with solder. When necessary, wipe the hot iron tip with a cloth. If you are using an old tip, clean it before you start soldering.

Use Only Rosin Core Solder

We supply the right kind of solder.

HERE'S HOW TO DO IT . . .

1. Join bare metal to bare metal. Make good mechanical connections and keep leads as short as possible.

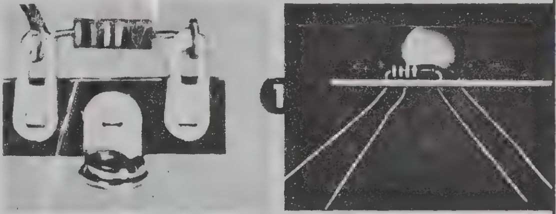
2. Coat the tip of your hot iron with solder. Then **Firmly Press the Tip** against the parts to be soldered.

Apply the solder between the metal to be soldered and the iron tip. Use only enough solder to flow over all surfaces and wires in the connection. Remove the iron.

If you accidentally move the wires as the solder is hardening, apply your iron and reheat.

3. Compare your soldering with these pictures. The connection is good if: solder flowed over all surfaces to be connected, it appears smooth and bright and all wires are held firmly by solder.

You Have Not Used Enough Heat: If your connection is rough and flaky-looking, or if the solder has formed a round ball instead of spreading.



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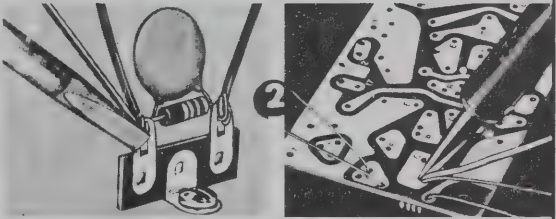

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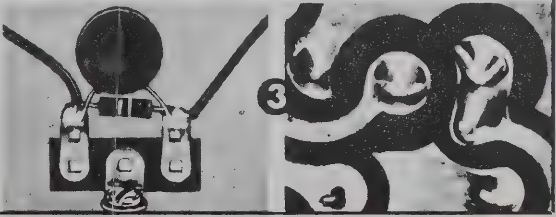

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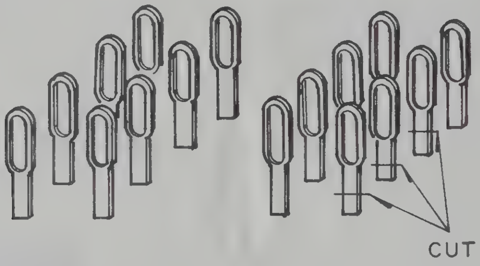
PREPARING YOUR TESTER FOR CONSTRUCTION

SEE FIGURE 1.

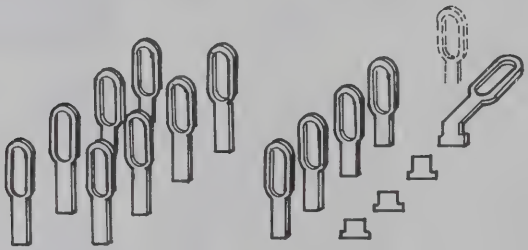
☑ Place a soft cloth over your work surface so you don't scratch the panel assembly or meter face.

☑ Position the Panel Assembly in front of you as shown.

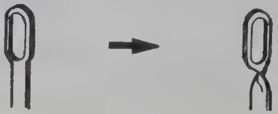
☑ Carefully study Figure 1 and the Detail shown below.
Use your wire cutters and carefully cut off 3 of the Switch terminals — be sure you cut off the correct ones.

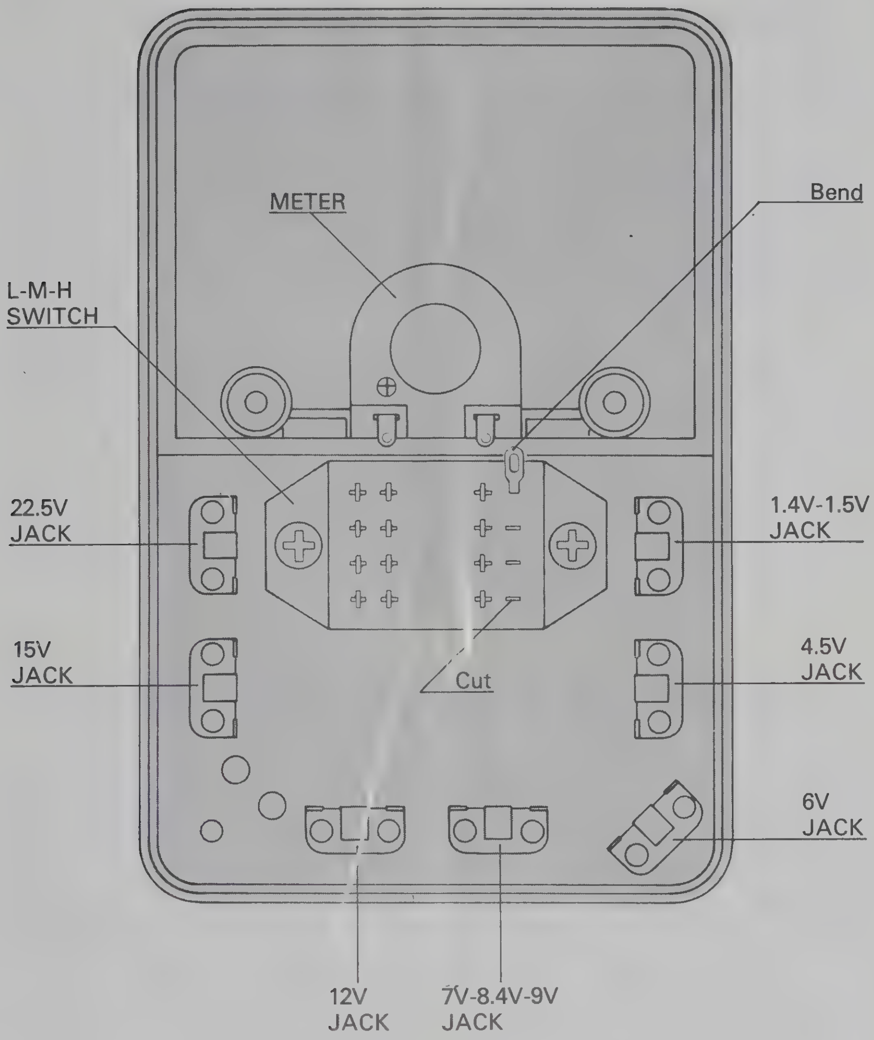


☑ Carefully bend over one terminal as shown.



☑ The remaining 12 terminals must be twisted at right angles. Do this carefully with your long-nose pliers.





METER
Bend
L-M-H SWITCH
22.5V JACK
1.4V-1.5V JACK
15V JACK
4.5V JACK
Cut
6V JACK
12V JACK
7V-8.4V-9V JACK

Figure 1.

ADDING RESISTORS AND WIRES

Now you are ready to make solder connections. We've given you some simple drawings to show you different types of solder connections.

Too Much Solder shows that when you melt too much solder into a connection, the solder runs down the terminal. If you use even more solder, it may run across the plastic and touch an adjacent terminal; this makes a "short circuit". This would keep your Tester from working properly. So, avoid "too much solder".

To correct such a connection, turn the Tester upside down and hold your hot soldering iron tip against the connection — the excess solder will run down onto the iron and away from the connection.

Cold Solder Connection shows a connection with about the right amount of solder — but the solder has not flowed smoothly over the entire connection. Either the wire was moved before the solder completely hardened, or not enough heat was applied with the iron (iron taken away too soon).

To correct a "cold" solder connection, reheat it. If solder does not make a smooth cover over the entire wire connection, you may want to add a **little** more.

A quick test to identify a "cold" solder connection — can you move any wire ends *in the connection*? If any wire moves *in the connection*, it's a "cold" solder connection!

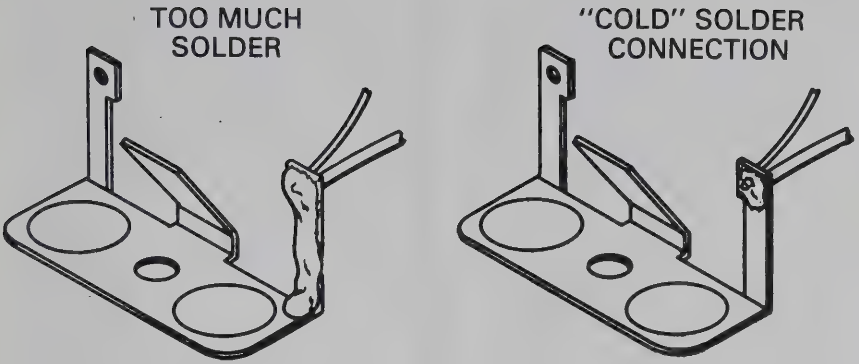
Too Little Solder is just that — not enough solder to completely cover the wires in a connection.

To correct this, melt a **small** amount of additional solder into the connection.

Just Right shows a solder connection with everything "just right". Not too much solder and an adequate amount of heat. The solder has flowed all over the wires in the connection. They are held firmly in the connection. The solder has a nice smooth metallic finish.

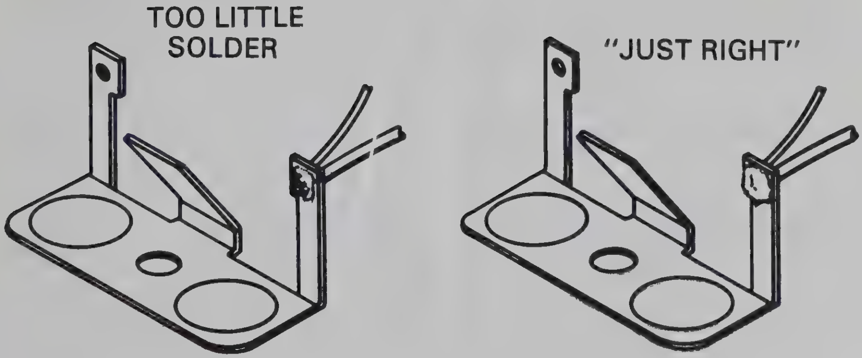
Now you know how to do it right!

Let's get on with building.



TOO MUCH SOLDER

"COLD" SOLDER CONNECTION



TOO LITTLE SOLDER

"JUST RIGHT"

Figure 2.

SEE FIGURE 3.

NOTES: Now is a good time to remind you of a couple of things:

1. Be sure the tip of your soldering iron is clean and well coated with a fresh layer of melted solder. A clean soldering iron tip makes good connections much easier. Radio Shack sells a soldering iron sponge to help you keep the tip nice and clean — get one and use it.
2. When you are making connections near the plastic panel and parts — take great care that you don't let the hot tip of your iron touch the plastic. It will melt and won't look very neat!

☑ R-1 is a 750 ohm resistor (marked Violet — Green — Brown). Cut each lead to about ½''(13 mm). Solder one lead to the 22.5V Jack and the other lead to the 15V Jack.

☑ R-2 is a 300 ohm resistor (marked Orange — Black — Brown). Cut each lead to about ½''(13 mm). Solder one lead to the 15V Jack and the other lead to the 12V Jack.

☑ R-3 is a 300 ohm resistor (marked Orange — Black — Brown). Cut each lead to about ½''(13 mm). Solder one lead to the 12V Jack and the other lead to the 7V-8.4V-9V Jack.

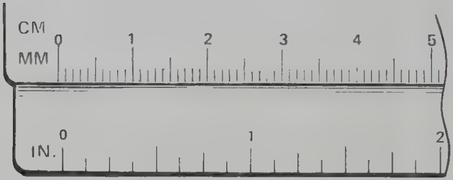
☑ R-4 is a 300 ohm resistor (marked Orange — Black — Brown). Cut one lead to about ½''(13 mm). Solder the short lead to the 7V-8.4V-9V Jack and the long lead to the Switch terminal shown.

☑ R-5 is a 150 ohm resistor (marked Brown — Green — Brown). Cut each lead to about ¼''(6 mm). Solder one lead to the 6V Jack and the other lead to the 4.5V Jack.

☑ R-6 is a 300 ohm resistor (marked Orange — Black — Brown). Cut each lead to about ½''(13 mm). Connect (don't solder yet) one lead to the 4.5V Jack and the other lead to the 1.4V-1.5V Jack.

☑ Pink wire. Solder one end to the Meter plus terminal. Solder the other end to the 1.4V-1.5V Jack (be sure both leads are well soldered in this connection).

☑ Pink wire. Solder one end to the 1.4V-1.5V Jack. Solder the other end to the Switch terminal shown.



SPECIFICATIONS

Voltage Ranges: 7 (1.4-1.5V, 4.5V, 6V, 7-8.4-9V, 12V, 15V and 22.5V)
Load Ranges: Low, Medium and High
(1.4 to 6 volts — all three ranges)
(7 to 22.5 volts — Low range only)
Load Current: Low = 10 milliamperes
Medium = 50 milliamperes
High = 150 milliamperes

Battery Good/Bad Check Points & Accuracy:

	UPPER EDGE OF "REPLACE"	LOWER EDGE OF "GOOD"	ACCURACY
1.4 & 1.5V	0.97V	1.10V	±0.15V
4.5V	2.91V	3.30V	±0.45V
6V	3.88V	4.40V	±0.60V
7, 8.4 & 9V	5.82V	6.60V	±0.90V
12V	7.76V	8.80V	±1.20V
15V	9.70V	11.0V	±1.50V
22.5V	14.6V	16.5V	±2.25V

OPERATION

☑ Carefully remove the adhesive-backed Battery Chart from its paper backing and press onto the back of the Tester. Press all edges down firmly so it will stick tightly.

For accurate readings, it is best to place the Tester on a non-metallic surface, with meter facing up.

Plug the Red Test Lead into the appropriate Voltage Jack. Select the correct L-M-H switch position (see Specifications and chart on the back of the Tester).

Connect the Black Test Lead to the negative side of the battery and Red to the positive side. If the Meter reads to the left (backwards), you have connected the leads backwards — reverse them.

Read the meter scale to determine the battery condition. A reading in the green zone indicates Good. A reading in the red zone indicates that the battery is dead and must be Replaced. If the reading is just between (or near) the two color scales, the battery is weak and its life is limited. Working battery life depends on the application — a "weak" battery might not operate a Tape Recorder or Toy, while it may operate a Radio.

NOTE: When testing batteries of 7 volts and over, use the L position. **On the higher voltage batteries, the M and H switch position will not function.**

SEE FIGURE 3.

NOTES: Now is a good time to remind you of a couple of things:

1. Be sure the tip of your soldering iron is clean and well coated with a fresh layer of melted solder. A clean soldering iron tip makes good connections much easier. Radio Shack sells a soldering iron sponge to help you keep the tip nice and clean — get one and use it.
2. When you are making connections near the plastic panel and parts — take great care that you don't let the hot tip of your iron touch the plastic. It will melt and won't look very neat!

☑ R-1 is a 750 ohm resistor (marked Violet — Green — Brown). Cut each lead to about ½''(13 mm). Solder one lead to the 22.5V Jack and the other lead to the 15V Jack.

☑ R-2 is a 300 ohm resistor (marked Orange — Black — Brown). Cut each lead to about ½''(13 mm). Solder one lead to the 15V Jack and the other lead to the 12V Jack.

☑ R-3 is a 300 ohm resistor (marked Orange — Black — Brown). Cut each lead to about ½''(13 mm). Solder one lead to the 12V Jack and the other lead to the 7V-8.4V-9V Jack.

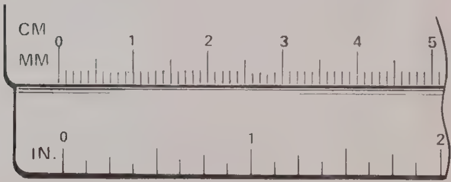
☑ R-4 is a 300 ohm resistor (marked Orange — Black — Brown). Cut one lead to about ½''(13 mm). Solder the short lead to the 7V-8.4V-9V Jack and the long lead to the Switch terminal shown.

☑ R-5 is a 150 ohm resistor (marked Brown — Green — Brown). Cut each lead to about ¼''(6 mm). Solder one lead to the 6V Jack and the other lead to the 4.5V Jack.

☑ R-6 is a 300 ohm resistor (marked Orange — Black — Brown). Cut each lead to about ½''(13 mm). Connect (don't solder yet) one lead to the 4.5V Jack and the other lead to the 1.4V-1.5V Jack.

☑ Pink wire. Solder one end to the Meter plus terminal. Solder the other end to the 1.4V-1.5V Jack (be sure both leads are well soldered in this connection).

☑ Pink wire. Solder one end to the 1.4V-1.5V Jack. Solder the other end to the Switch terminal shown.



☑ Red wire. Solder one end to the 4.5V Jack (be sure both leads are well soldered). Solder the other end to the Switch terminal shown.

☑ Yellow wire. Solder one end to the 6V Jack. Solder the other end to the Switch terminal shown.

☑ R-8 is a 10 ohm resistor (marked Brown — Black — Black). Cut one lead to about 1/8''(3 mm); cut the other lead to about ¾''(20 mm). Bend the longer lead so you can install the resistor as shown. Solder the shorter lead to the terminal shown (don't solder the longer lead yet — another wire will be added later).

☑ R-10 is a 20 ohm resistor (marked Red — Black — Black). Cut one lead to about 1/8''(3 mm); cut the other lead to about ¾''(20 mm). Bend the lead so you can install the resistor as shown. Solder the long lead to the Switch terminal shown (don't solder the short lead yet — another wire will be added later).

☑ R-12 is a 10 ohm resistor (marked Brown — Black — Black). Cut one lead to about ¼''(6 mm); cut the other lead to about ¾''(20 mm). Bend the lead so you can install the resistor as shown. Solder the long lead to the Switch terminal shown (don't solder the short lead yet — other wires will be added later).

☐ R-9 is a 36 ohm resistor (marked Orange — Blue — Black). Cut one lead to about 1/8''(3 mm); cut the other lead to about ¾''(20 mm). Bend the lead so you can install the resistor as shown. Solder the long lead to the Switch terminal shown (don't solder the short lead yet — another wire will be added later).

☑ R-11 is a 75 ohm resistor (marked Violet — Green — Black). Cut one lead to about 1/8''(3 mm); cut the other lead to about ¾''(20 mm). Bend the lead so you can install the resistor as shown. Solder the long lead to the Switch terminal shown (don't solder the short lead yet — another wire will be added later).

☐ R-13 is a 36 ohm resistor (marked Orange — Blue — Black). Cut one lead to about 5/8''(16 mm); cut the other lead to about ¾''(20 mm), bend the longer lead so you can install the resistor as shown. Solder the longer lead to the terminal shown (don't solder the shorter lead yet — other wires will be added later).

☐ R-7 is a 150 ohm resistor (marked Brown — Green — Brown). Cut each lead to about 3/8''(10 mm). Solder one lead to the Meter minus terminal and the other lead to the Switch terminal shown (be sure both leads are well soldered in this connection).

☑ Insert the free end of the Black Test Lead up through the ⊖ CORD hole in the front panel. Tie a knot at the inside of the Panel about 1-¾''(45 mm) from the end. Solder the end of this wire to the Switch terminal and/or wire leads where shown. Be sure each wire is soldered at these switch terminals.

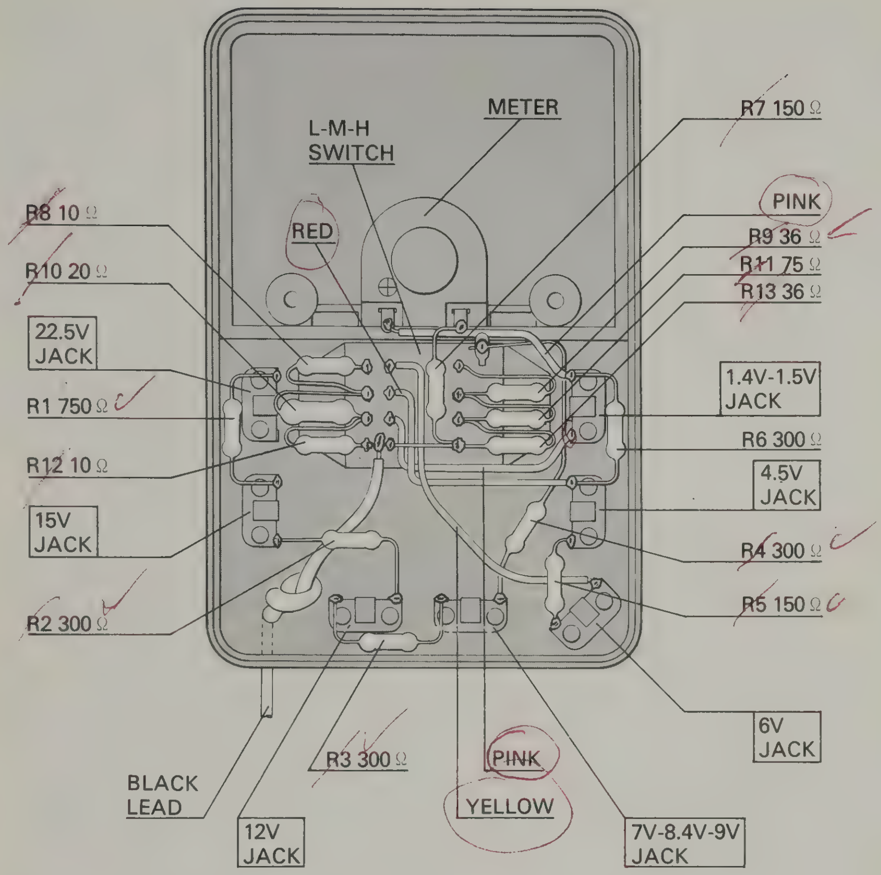


Figure 3.

Your Tester is now ready for use. Before you put the case together, check all your soldering very carefully. Check Figure 2 again and be sure all your solder connections are "Just Right". Be sure the parts are positioned neatly as shown. Make sure no bare wire leads touch each other — or touch against an adjacent terminal or jack.

Now, when you are sure everything is OK, fasten the case back to the panel assembly with the screws.

PARTS LIST

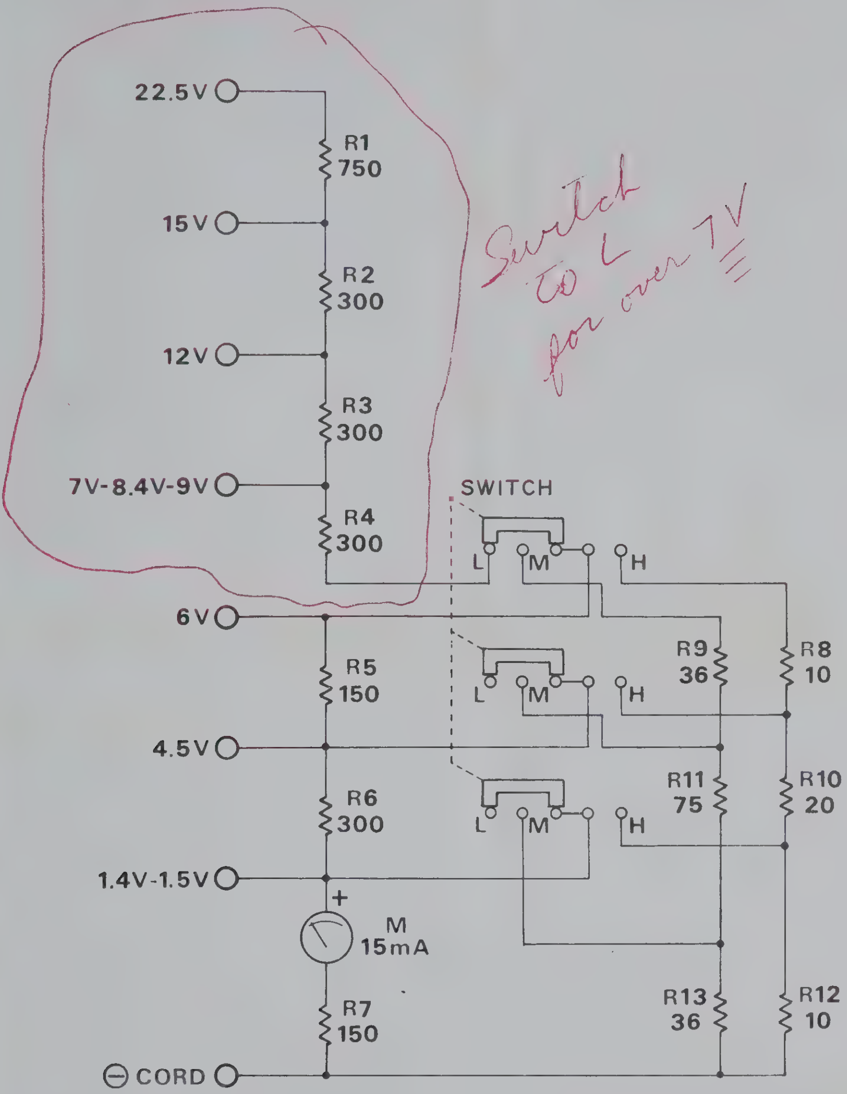
RESISTORS

Symbol No.	Description		
R-1	750 Ω	(violet, green, brown)	¼W, 5 %
R-2	300 Ω	(orange, black, brown)	¼W, 5 %
R-3	300 Ω	(orange, black, brown)	¼W, 5 %
R-4	300 Ω	(orange, black, brown)	¼W, 5 %
R-5	150 Ω	(brown, green, brown)	¼W, 5 %
R-6	300 Ω	(orange, black, brown)	¼W, 5 %
R-7	150 Ω	(brown, green, brown)	¼W, 5 %
R-8	10 Ω	(brown, black, black)	¼W, 5 % or 10 %
R-9	36 Ω	(orange, blue, black)	¼W, 5 % or 10 %
R-10	20 Ω	(red, black, black)	½W, 5 % or 10 %
R-11	75 Ω	(violet, green, black)	¼W, 5 % or 10 %
R-12	10 Ω	(brown, black, black)	¼W, 5 % or 10 %
R-13	36 Ω	(orange, blue, black)	¼W, 5 % or 10 %

MISCELLANEOUS

Description	Quantity
Panel assembly with Meter and jacks	1
Case back	1
L-M-H Switch	1
Screw, Phillips, self-threading (3 × 6 mm)	2
Solder (25 cm)	1
Test leads (Black & Red)	1 pair
Wire, Pink (40 mm)	2
Wire, Red (50 mm)	1
Wire, Yellow (60 mm)	1

SCHEMATIC DIAGRAM


22.5V
R1
750
15V
R2
300
12V
R3
300
7V-8.4V-9V
R4
300
SWITCH
L
M
H
6V
R5
150
R9
36
R8
10
4.5V
R6
300
R11
75
R10
20
1.4V-1.5V
+
M
15mA
R7
150
R13
36
R12
10
⊖ CORD

Switch to L for over 7V

NOTES: ALL RESISTOR VALUES ARE GIVEN IN OHMS

RADIO SHACK A DIVISION OF TANDY CORPORATION
U.S.A.: FORT WORTH, TEXAS 76102
CANADA: BARRIE, ONTARIO, CANADA L4M 4W5

TANDY CORPORATION

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7A6

Printed in Korea

New Absorption Frequency Meter

TRIPLETT

Model 3256
With High Sensitivity—Covers Five Amateur Bands

A band-switching, tuned absorption type frequency meter covering five amateur bands. Incorporates the new germanian crystal and a DC Milliammeter indicator for greater sensitivity. Direct calibration on panel—no coils to change; switching permits instantaneous band change. Audio jack provided for monitoring of phone signals—another new feature. Fully shielded. Calibration is in megacycles in the following bands:

3.5- 4
7 - 7.3
14 -14.4
20 -21.5
28 -30

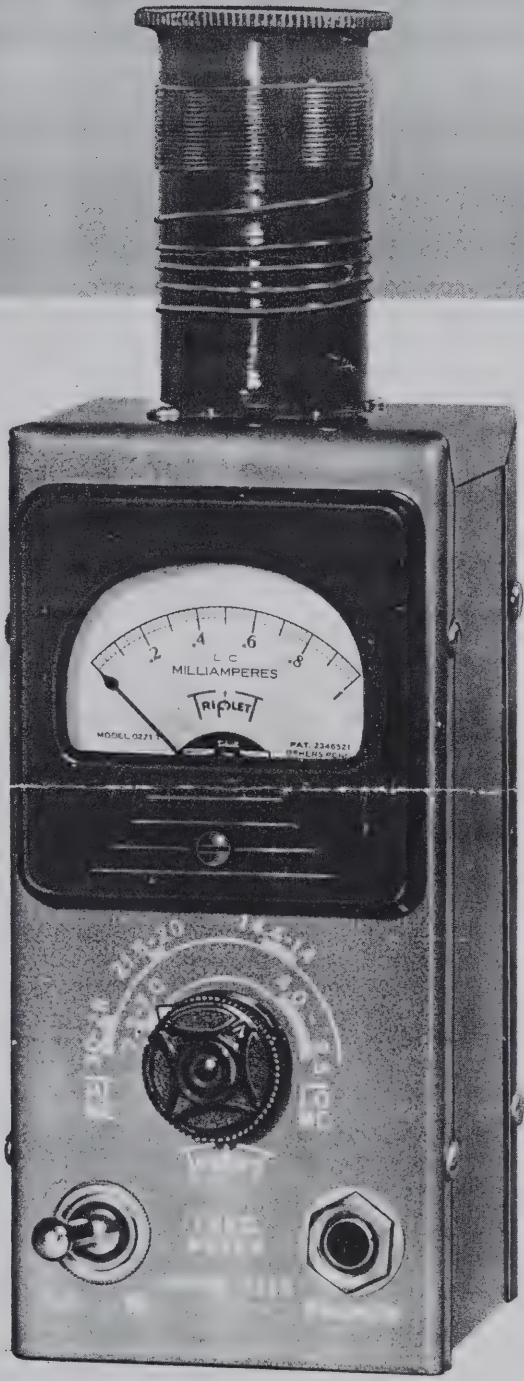
Coil is removable and other coils may be substituted for special bands.

USEFUL FOR CHECKING:

1. Fundamental frequency of oscillating circuits.
2. Presence, order, and amplitude of harmonics.
3. For parasitic oscillations.
4. The neutralization of R. F. amplifiers.
5. Standing wave ratio on transmission lines.
6. The presence of undesirable R. F.
7. For small quantities of R. F.
8. Monitoring of phone signals.

CASE DESCRIPTION

A fully shielded, highly sensitive unit in handy, compact pocket size—adapted for use in restricted spaces. Case size: Overall height, including coil, 7½"; width, 2½"; depth, 2¼". Attractive gray hammered enamel finish with black trim. U.S.A. Amateur Net Price......**$14.75**



Model 3256

Triplett also offers a complete line of panel and portable meters in 26 case styles—voltmeters, ammeters, milliammeters, millivoltmeters, microammeters, thermo ammeters, DB meters, VU meters and electrodynamometer type instruments.

THE TRIPLETT ELECTRICAL INSTRUMENT CO.
BLUFFTON, OHIO

Model 3256 Absorption Frequency Meter

GENERAL DESCRIPTION

The 3256 Absorption Frequency Meter is a highly sensitive absorption type using a 0-1 Ma. meter as the tuning indicator. One coil is used for the most popular amateur bands: 3.5-4.0; 7.0-7.3; 14-14.4; 20-21.5; and 28-30 megacycles divided into two bands marked on the panel as Lo and Hi. The Lo band covers the frenquencies 3.5 to 7.3 megacycles and the Hi band 14 to 30 megacycles. The black knob with white pointer, centrally located on the front panel, is the frequency tuning control and is tunable through 180 degrees as indicated on the calibrated scale. The phone jack marked "PHONES" provides a means for monitoring phone signals.

PURPOSE

This instrument was primarily designed to provide a quick and sensitive means for approximating the frequençies generated by transmitter vacuum tube oscillators, buffer amplifiers and final amplifiers.

USES

1. To approximate the frequency of a transmitted signal.
2. To check fundamental and harmonic frequencies of oscillators, buffer amplifiers, and final amplifiers.
3. To measure standing waves on transmission lines.
4. To check for parasitic oscillations in the various transmitter stages.
5. To neutralize an amplifier stage.
6. To monitor the quality of a transmitted phone signal.

HOW TO USE

Place the coil of the 3256 relatively close to the inductance whose frequency you desire measuring and with the stage operating, carefully tune the absorption frequency meter for maxiumm meter swing. The white pointer on the tuning knob will point to the approximate frequency being generated by this stage. How closely this instrument must be coupled to the measured stage will be determined by the power generated in the stage; the maximum swing on the meter should generally not exceed .6-.8 Ma. On high power stages, R. F. transfer may be obtained at distances up to several feet, while in low power stages it may be necessary to hold the frequency meter coil within an inch or two of the transmitting inductance.

Since this instrument is highly sensitive to R. F. energy, the harmonics being generated by a transmitting stage can easily be measured and can be distinguished by comparing the relative signal strength readings indicated on the meter. (CAUTION: Be sure coupling and transmitter conditions are exactly the same when checking for harmonics.) The strongest signal will be the fundamental; the next strongest tunable signal will be the second harmonic; etc. The second harmonic is usually about one-half as strong as the fundamental.

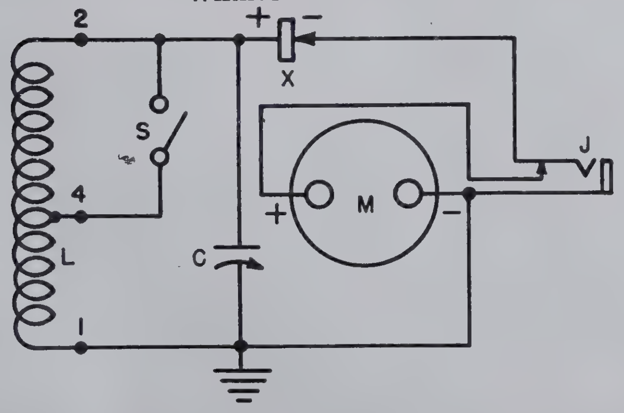
To monitor the phone transmitter, couple the frequency meter so that when tuned to the transmitted frequency a reading of approximately .4-.6 Ma. is indicated on the meter. Next plug head phones into the jack marked "PHONES"; this will cause the meter to read zero as the meter is disconnected when phones are plugged in for monitoring. The A. F. modulation of the transmitter should now be heard.

To measure **standing wave ratio,** tune the frequency meter to the transmitter frequency with the antenna tuned and operating. Move the frequency meter along the transmission line, being careful to keep the coil the same distance from feed line all the way, and note the change in reading on the meter. By comparing the maximum readings with the minimum readings obtained, the standing wave ratio can be determined. The less the variation in readings, the lower the ratio; therefore, the transfer of energy will be more sufficient through the feed line to the antenna.

To check for **parasitic oscillations,** bring the coil of the frequency meter near the amplifier inductance and tune over the various bands noting the frequencies at which the meter swings up, also change the tuning of the measured stage and see if the readings are influenced. Remove excitation from stage (be sure it is biased down sufficiently or does not draw too much plate current) and check for possible radiation. Note the frequencies, if any, indicated on the frequency meter.

To neutralize an **amplifier stage,** remove plate current from the stage being neutralized; however, provide the normal excitation to the grid. Now bring the coil of the frequency meter close to the plate inductance of the amplifier and tune to the transmitter frequency noted by maximum swing on the indicator of the frequency meter. Holding these conditions constant, tune the neutralizing condenser until frequency meter gives the lowest possible reading. It may be necessary to retune the amplifier plate condenser for maximum reading of frequency meter two or three times during this procedure, however, continue the procedure until a minimum reading on the frequency meter is obtained. The stage will now be properly neutralized if the adjustments were carefully made.

WIRING DIAGRAM



REPLACEABLE PARTS LIST—3256

C	Capacitor, 140MMFD Variable	T-43-49
J	Jack, closed circuit phone	T-3215-6
L	Coil Assembly, plug-in	T-2542-61
S	Switch, SPST toggle	T-2439-12
M	Instrument Assembly 0-1 Ma. 227-T	
X	Crystal Diode, 1N34	9423
1	Coil Pin bottom of winding	
2	Coil Pin top of winding	
4	Coil Pin center tap	
	Case, Side	T-10-583
	Case, front screened	T-10-582
	Knob, round with pointer	T-2558-4

Model 3256

THE TRIPLETT ELECTRICAL INSTRUMENT CO.
BLUFFTON, OHIO

Form 12147-T

PRINTED IN U

FORM 856 - 7-1-41

INSTRUCTIONS FOR OPERATING PRECISION SERIES 856G
DUAL-SENSITIVITY MULTI-RANGE TESTER
20,000 and 1000 ohms per volt D.C. - 1000 ohms per volt A.C.

The Series 856 represents a new type of laboratory multi-range tester, designed and developed by Precision engineers to meet the requirements for a high sensitivity instrument for accurate measurements in high resistance circuits -- yet an instrument that can, (at the flip of a switch) be immediately converted to a 1000 ohms per volt unit for standard sensitivity measurements in conformance with the point to point voltage reading specifications furnished by receiver manufacturers and in service manuals.

The Series 856 high sensitivity multi-range tester is ideal for obtaining reliable measurements in modern radio (A.M. and F.M.) and television circuits where only minute current drain of the measuring instrument can be tolerated. The more than adequate circuit sensitivity of the Series 856 will provide accurate voltage, current and resistance measurements in all television and F.M. networks; AFC and AVC circuits; resistance coupled amplifier channels; grid bias and grid current in AF and RF networks and other circuit measurements previously unattainable.

Through use of a highly advanced rotary selective switching system, all A.C. and D.C. ranges, commonly employed, are available at only two highly insulated polarized tip jacks. As a precaution against meter overloads, as well as for safety of the operator, 8 additional heavy duty pin jacks are provided for the following extended ranges:

60 and 300 microamperes, 12 amperes, 1200 volts, 6000 volts and OUTPUT.

The Series 856 HIGH SENSITIVITY TESTER provides for the following:

① Seven D.C. voltage ranges at 20,000 ohms per volt: 2% accuracy
0-3; 0-12; 0-60; 0-300; 0-600; 0-1200; 0-6000 volts.

② Seven D.C. voltage ranges at 1000 ohms per volt: 2% accuracy
0-3; 0-12; 0-60; 0-300; 0-600; 0-1200; 0-6000 volts.

③ Seven A.C. voltage ranges at 1000 ohms per volt: 3% accuracy
0-3; 0-12; 0-60; 0-300; 0-600; 0-1200; 0-6000 volts.

④ Seven D.C. current ranges: 2% accuracy
0-60; 0-300 microamperes
0-3; 0-30; 0-120; 0-600 MA; and 0-12 Amps.

⑤ Three Resistance ranges:
0-6000 ohms (35 ohms center)
0-600,000 ohms (3500 ohms center)
0-60 megohms (350,000 ohms center)

⑥ Six Decibel ranges from -12 to +70 DB.

⑦ Seven Output ranges:
0-3; 0-12; 0-60; 0-300; 0-600; 0-1200; 0-6000 volts.

⑧ D.C. Current measurements of leakage in electrolytic condensers.

⑨ Qualitative Paper Condenser Tests.

OPERATING INSTRUCTIONS

Although this instrument provides the utmost simplicity in operation, it is nevertheless advisable that the user initially take note of the following information.

The three position switch, located at the lower right hand portion of the panel shall be referred to, (in what is to follow) as the "CIRCUIT SELECTOR". The extreme left hand position of this switch, labelled "D.C.-1000 OHMS PER VOLT", is employed ONLY for D.C. VOLTAGE measurements at standard 1000 ohms per volt sensitivity. The center position, labelled "A.C.", is employed ONLY for A.C. VOLTAGE (DB and output) tests at 1000 ohms per volt sensitivity. The third, extreme right hand position, labelled "D.C.-20,000 OHMS PER VOLT" provides for all other functions of the instrument, which utilize the full sensitivity of the meter, namely; D.C. VOLTAGE measurements at 20,000 ohms per volt; ALL D.C. CURRENT measurements; ALL RESISTANCE ranges.

The "MASTER RANGE SELECTOR", at the center of panel, provides complete and rapid selection of all commonly employed ranges, and operates in conjunction with the correct "CIRCUIT SELECTOR" position for the range desired. The actual employment of the foregoing, as well as the remaining panel components, will be found described with each of the individual test functions.

A.C. VOLTAGE MEASUREMENTS: 1000 ohms per volt sensitivity

Set "CIRCUIT SELECTOR" switch to the "A.C" position for all A.C. voltage measurements. For A.C. voltage measurements up to 600 volts, select desired range on rotary "MASTER RANGE SELECTOR". Insert test leads into polarized "TEST" tip jacks and read on proper RED A.C. CORRECTION SCALE as follows:

0-3 volts read directly on separate "3V-A.C.only" Red scale
0-12 volts read on 120 scale, divide by 10
0-60 volts read directly
0-300 volts read on 30 scale, multiply by 10
0-600 volts read on 60 scale, multiply by 10
0-1200 volts read on 120 scale, multiply by 10
0-6000 volts read on 60 scale, multiply by 100

For A.C. VOLTAGE MEASUREMENTS ABOVE 600v. and to 6000v., set rotary "MASTER RANGE SELECTOR" to the 600v. position. Insert one test lead into the negative (-) "TEST" tip jack, and the other test lead into the appropriate "1200v. AC-DC" or "6000v. AC-DC" tip jack located at upper right hand corner of instrument panel and read on A.C. CORRECTION SCALE as above.

D.C. VOLTAGE MEASUREMENTS: 20,000 ohms per volt sensitivity

Set "CIRCUIT SELECTOR" switch to the "D.C.-20,000 ohms per volt" position for all D.C. voltage measurements at this high sensitivity. For voltage measurements up to 600 volts, select desired range on rotary "MASTER RANGE SELECTOR". Insert test leads into polarized "TEST" tip jacks and read on D.C. scale as follows:

0-3 volts read on 30 scale, divide by 10
0-12 volts read on 120 scale, divide by 10
0-60 volts read directly
0-300 volts read on 30 scale, multiply by 10
0-600 volts read on 60 scale, multiply by 10
0-1200 volts read on 120 scale, multiply by 10
0-6000 volts read on 60 scale, multiply by 100

For D.C. (20,000 ohms per volt) VOLTAGE MEASUREMENTS ABOVE 600v. and to 6000v., set rotary "MASTER RANGE SELECTOR" to the 600v. position. Insert one test lead into the negative (-) "TEST" tip jack and other test lead into the appropriate "1200v. AC-DC" or "6000v. D.C. 20,000 ohms per volt" tip jack located at upper right hand corner of instrument panel, and read on D.C. scale as above.

D.C. VOLTAGE MEASUREMENTS: 1000 ohms per volt sensitivity

Set "CIRCUIT SELECTOR" switch to the "D.C.-1000 ohms per volt" position for all D.C. voltage measurements at this sensitivity. For voltage measurements up to 600 volts, select desired range on rotary "MASTER RANGE SELECTOR". Insert test leads into polarized "TEST" tip jacks and read on D.C. scale as follows:

0-3 volts read on 30 scale, divide by 10
0-12 volts read on 120 scale, divide by 10
0-60 volts read directly
0-300 volts read on 30 scale, multiply by 10
0-600 volts read on 60 scale, multiply by 10
0-1200 volts read on 120 scale, multiply by 10
0-6000 volts read on 60 scale, multiply by 100

For D.C. (1000 ohms per volt) VOLTAGE MEASUREMENTS ABOVE 600v. and to 6000v., set rotary "MASTER RANGE SELECTOR" to the 600v. position. Insert one test lead into the negative (-) "TEST" tip jack and the other test lead into the appropriate "1200v. AC-DC" or "6000v. D.C.-1000 ohms per volt" tip jack located at upper right hand corner of instrument panel, and read on D.C. scale as above.

CAUTION: When employing the 1200v. and 6000v. ranges, for measurements in extra high voltage circuits, extreme care must be observed in the manner of handling test prods, tip jacks and high voltage circuits under analysis. We recommend, for this purpose, only the use of "PRECISION" extra-high voltage super-flex test leads, (Part #228) which have been pecifically designed for full safety of operation up to 6000 volts D.C. and 60 cycle A.C.

It is important to note that although both 20,000 and 1000 ohms per volt measurements are available at a SINGLE 1200v. jack, (labelled AC-DC ⌿ 1200v.), there are TWO jacks employed for the 6000 volt range: The upper right hand jack is employed ONLY for the 6000 volt "20,000 ohms per volt D.C." range, whereas the jack directly below it is employed for the 6000 volts "1000 ohms per volt AC-DC" range.

NOTE: All voltage measurements are made with test leads applied across load. Observe proper polarity at tip jacks.

IMPORTANT PRECAUTIONS
When Testing High Voltage Circuits

Whenever making voltage measurements in ANY circuits wherein the potentials exceed 3000 volts, it is advisable for the operator to connect the instrument panel to a good GROUND. The cold water pipe is usually sufficient. Connection should be made from ground source to under one of the etched instrument panel border mounting screws.

This practice will protect the operator at all times from electrostatic charges which may readily accumulate on instrument panel, or in the case of metal cased units, on both case and panel.

* * * *

BEFORE making ANY MEASUREMENTS in a Television Receiver or in ANY OTHER DEVICE wherein the POSITIVE (+) side of the high voltage power supply is connected to chassis, it is absolutely IMPERATIVE that all EXTERNAL ground connections be removed. This includes the following:

1. DISCONNECT ANY external grounding leads (such as from radiators, cold water pipes or power line neutrals) which may be connected (directly or through a condenser) to the receiver or device upon which measurements are to be made.
2. COMPLETELY DISCONNECT ALL power line by-pass condensers from their connection to the A.C. line cord or power transformer primaries.

* * * *

NEVER attempt adjustment or test of any circuits (such as television receivers) wherein exceedingly dangerously high voltages are present unless a complete circuit diagram is available to identify the location of all high potential terminals. Always employ well insulated test leads, such as the PRECISION Extra-High Voltage Super-Flex Test Leads, Part #228. Available from distributor.

* * * *

Make sure hands and shoes are DRY when performing tests wherein high voltage is involved.

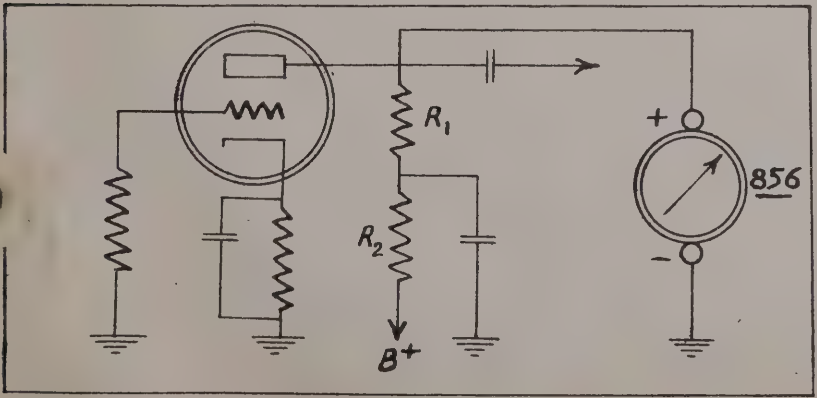
* * * *

IMPORTANT INFORMATION - TAKE NOTE

Inasmuch as this instrument provides for D.C. voltage measurements at both 20,000 and 1000 ohms per volt, it is natural that at some time or other the operator will take a reading at a particular test point, first employing one sensitivity and then the other.

In the greatest majority of cases, even though the same range be employed, the indication obtained at 20,000 ohms per volt will be greater than that obtained with the instrument set for 1000 ohms per volt. The difference in readings will be directly proportional to the effective resistance included in the circuit under test.

This is readily understood by viewing a simple example:



Let us assume it is desired to determine whether voltage exists at the plate of our representative resistance coupled amplifier: Your instrument test prods are connected accordingly and a meter reading obtained. However, it must be realized that this reading includes the current drain of your meter through R1 and R2. Hence, the less will the voltage drop be, and therefore a higher and truer voltage indication will be obtained, at 20,000 ohms per volt than at 1000 ohms per volt.

Of course, if R1 and R2 be replaced in the circuit by an audio transformer, (wherein the D.C. primary resistance is almost negligible for purposes of discussion) the difference in voltage reading at 20,000 and 1000 ohms per volt will not be so noticeable.

We may therefore conclude that it is at all times more desirable to employ the highest sensitivity and thereby least disturb the circuit operating conditions; unless point to point voltage tests are being made in comparison with a list of expected readings, (as sometimes furnished by receiver manufacturers or in service manuals), and 1000 hms per volt sensitivity is specified as the basis for the voltage readings listed.

.C. CURRENT MEASUREMENTS:

Set "CIRCUIT SELECTOR" switch to the "D.C.-20,000 ohms per volt" position for all D.C. current measurements. For D.C. CURRENT RANGES OF 3 MA TO 600 MA INCLUSIVE, select desired range on rotary "MASTER RANGE SELECTOR". Insert test leads into polarized "TEST" tip jacks and read on D.C. scale as follows:

0-3 MA read on 30 scale, divide by 10
0-30 MA read directly
0-120 MA read directly
0-600 MA read on 60 scale, multiply by 10

FOR THE 60 AND 300 MICROAMPERE RANGES, set rotary "MASTER RANGE SELECTOR" to the 30 MA position. Insert negative test lead into the negative (-) "TEST" tip jack and the positive lead into the appropriate 60 microamp or 300 microamp positive (+) tip jack located at upper left hand corner of instrument panel and read on D.C. scale as follows:

0-60 microamps read directly
0-300 microamps read on 30 scale, multiply by 10

FOR THE 12 AMPERE RANGE, set rotary "MASTER RANGE SELECTOR" to the 600 MA position. Insert test leads into the polarized "12 AMP" tip jacks located at lower left hand corner of instrument panel and read on D.C. scale as follows:

0-12 AMPS read on 120 scale, divide by 10

NOTE: When using the 12 Ampere D.C. range, never remove tip jacks while current is flowing through the circuit. Failure to observe this would result in arcing at the tip jacks being removed and though it would not injure the meter, the jack would gradually char.

All current measurements are made with test leads in SERIES with load. Observe proper polarity at tip jacks.

CAUTION: WHEN VOLTAGE OR CURRENT OF UNKNOWN VALUE IS TO BE MEASURED, IT IS ADVISABLE TO EMPLOY THE HIGHEST RANGE FIRST. IF METER INDICATION IS SLIGHT, THEN SELECT NEXT LOWER RANGE, ETC. ADHERE CLOSELY TO THE ABOVE IN ORDER TO PREVENT SLAMMING OF METER POINTER AND METER OVERLOADING.

RESISTANCE MEASUREMENTS:

Set "CIRCUIT SELECTOR" switch to the "D.C.-20,000 ohms per volt" position for ALL resistance measurements. Set "RANGE SELECTOR" to desired ohmmeter range and with "TEST tip jacks shorted, rotate "ADJUST OHMS" control to obtain full scale deflection before taking ohmmeter measurements for range being employed.

Resistance measurements are read directly on OHMS meter scale as follows:

0-6000 ohms range, read directly
0-600,000 ohms range, multiply reading obtained by 100
0-60 megohms range, multiply reading obtained by 10,000

CAUTION: ALWAYS FIRST DISENGAGE ONE END OF RESISTANCE FROM THE CIRCUIT BEFORE MAKING RESISTANCE MEASUREMENTS, OR ELSE AN INDICATION OF THE TRUE RESISTANCE VALUE MAY NOT BE OBTAINED DUE TO THE POSSIBILITY OF THE CIRCUIT THEREIN INVOLVED EFFECTIVELY SHUNTING THE RESISTANCE TO BE MEASURED, THUS REDUCING THE TRUE READING BY AN AMOUNT PROPORTIONATE TO THE RESISTANCE OF THE INCLUDED SHUNT NETWORK.

NOTE: The ohmmeter ranges of this instrument are powered by Eveready 1½ volt (#950) and Burgess (type #4156) 22½ volt batteries or equivalents. These batteries should be replaced when full scale deflection can no longer be obtained. Both batteries are mounted on inside of case.

OUTPUT METER INDICATIONS:

The A.C. voltage measurements at a high sensitivity of 1000 ohms per volt makes this instrument ideally suitable for use as an output meter.

There are two methods that can be used for obtaining output meter indications as listed below:

In the first method, make connections from the voice coil of speaker or secondary of output transformer to "TEST" tip jacks. In the event that easy access to the voice coil or secondary of transformer cannot be had, then refer to method outlined below:

In the second method, make connections from plate of output tube and ground or chassis of radio receiver to "OUTPUT" tip jack and plus "TEST" tip jack. A .1 mfd. 600 volt condenser is incorporated in the tester in series with the "OUTPUT" tip jack to block the D.C. component.

NOTE: When employing voltage ranges beyond 600 volts for output indications, it is necessary to insert an additional .1 mfd. condenser in series with one of the test leads. The voltage rating of this external condenser should be comparable to the maximum voltage appearing at the circuit being measured.

PROCEDURE: With the use of either method, noted above, set "CIRCUIT SELECTOR" switch to "A.C." position and rotate "RANGE SELECTOR" to highest voltage range. An output meter indication will be had when a signal generator and radio receiver are put into operation. If the meter indication is slight, then use the next lower A.C. voltage range, etc.

Any gain or loss by reason of balancing or trimming will accordingly be noted by corresponding meter pointer deflection.

NOTE: The output meter can also be used to great advantage for obtaining comparisons in tube performance by noting the difference in meter indications when any or all of the tubes are substituted in the radio receiver under test.

DECIBEL METER:

This instrument incorporates a direct reading and calibrated decibel scale enabling readings from -12 to +70 DB, in six ranges.

The initial scale reading (-12 to +16 DB) is based upon a zero level of 6 milliwatts (or 1.73 volts) across a 500 ohm load, 500 ohms being that most commonly employed in audio work. The most common use of a decibel meter is that of a power level indicator across known impedances. Because of calibration at one definite impedance, conversions must be made to the new impedance when used at other than 500 ohms. Such tables may be found in a multiplicity of textbooks and other technical publications.

Refer to Decibel Conversion table, last page of this booklet, for interpretation of decibel readings in terms of power, power ratios, voltage and voltage ratios.

Caution must be observed in the use of the DB ranges that the circuit across which the meter is placed is isolated from all D.C., else the meter may be damaged or at least erroneous readings obtained, depending upon whether the D.C. voltage is greater or less than the voltage scale to which the decibel scale corresponds.

PROCEDURE: Make connections across 500 ohm load to "TEST" tip jacks. Set "CIRCUIT SELECTOR" switch to the "A.C." position for all DECIBEL READINGS. Select desired DB range on rotary "MASTER RANGE SELECTOR" as follows:

0 DB range, read directly on initial DB scale (-12 to +16 DB)
+14 DB range, " " " " " " and add +14 DB
+28 DB range, " " " " " " and add +28 DB
+34 DB range, " " " " " " and add +34 DB
+40 DB range, " " " " " " and add +40 DB
+54 DB range, " " " " " " and add +54 DB

(Use "1200v. A.C.-D.C." tip jack for +40 DB range and "6000v. A.C.-D.C. tip jack for +54 DB range, with rotary "MASTER RANGE SELECTOR" at 600 volt position.)

CURRENT MEASUREMENTS OF LEAKAGE IN ELECTROLYTIC CONDENSERS:

The leakage in an electrolytic condenser is measured in terms of D.C. current per microfarad) flowing through the condenser when rated D.C. voltage is applied.

All electrolytic condensers contain an inherent current leakage. However, if leakages above an allowable amount are present, it can then be termed as poor. An allowable current leakage is dependent upon such factors as age and manufacturers' specifications of a condenser, design of power unit, filter system and rectifier tube of the radio receiver in which the condenser is incorporated. In general, considering an 8 mfd. condenser THAT HAS BEEN IN USE (rated at 450 volts), the maximum allowable leakage is approximately .5 MA per microfarad or 4 MA total.

The following will serve as a basis for computing approximate allowable leakages:

a) for condensers rated at 300 volts or more, leakages of approximately .5 MA per microfarad are permissible.
b) for condensers rated between 100 to 275 volts, permissible leakages are approximately .2 MA per microfarad.
c) for condensers rated below 100 volts, permissible leakages are approximately .1 MA per microfarad.

CAUTION: WHEN OBTAINING ELECTROLYTIC LEAKAGE MEASUREMENTS, HIGH VOLTAGE IS EMPLOYED. IT IS THEREFORE EXTREMELY IMPORTANT THAT THE FOLLOWING INSTRUCTIONS BE ADHERED TO IMPLICITLY TO PREVENT DAMAGE TO METER.

PROCEDURE:

With condenser disconnected from radio receiver circuit, CHECK CONDENSER FOR SHORT with ohmmeter, using the 0-600,000 ohms range. POLARITIES MUST BE OBSERVED. The negative "TEST" tip jack is connected to outside can or negative terminal of condenser and the positive "TEST" tip jack is connected to the anode (positive) terminal of condenser. A decided low resistance reading or constant full scale deflection of ohmmeter pointer indicates that the condenser is shorted and should be rejected WITHOUT FURTHER TESTING.

When an electrolytic incorporated in a radio receiver is to be tested, the necessary rated voltage is automatically applied and the following connections are made for "forming" and measuring the current leakage, after being (ohmmeter) tested for short.

1. Set "CIRCUIT SELECTOR" switch to the "D.C.-20,000 ohms per volt" position and rotate "MASTER RANGE SELECTOR" to the 120 MA position.

2. Remove lead from (positive) anode terminal of condenser and connect this lead to the positive "TEST" tip jack with A PROPER LIMITING RESISTOR IN SERIES. (Where voltage applied to condenser is above 100 volts, the limiting resistor should be approximately 4000 ohms. When the applied voltage is below 100 volts, the value of the limiting resistor should be approximately 900 ohms. This limiting resistor is very important and should not be omitted.

3. Connect the negative "TEST" tip jack to the (positive) anode terminal of condenser. (From the above connections, it can be seen that the "TEST" tip jacks, limiting resistor, condenser terminals and voltage source are in series connection.)

4. After series connections are made, turn on switch of radio set. The meter pointer will now deflect to near full scale and then gradually recede to the zero mark or near zero, after the expiration of about three minutes. THIS PROCEDURE IS KNOWN AS "FORMING" THE CONDENSER.

   NOTE: A steady meter pointer indication without receding to or near zero (after forming process) indicates a shorted or leaky electrolytic and the condenser should be rejected WITHOUT FURTHER TESTING.

5. After "forming", short out the limiting resistor and read current leakage of condenser under test, directly on the 120 MA scale. If meter indication is under 30 MA, set RANGE SELECTOR to the 30 MA position for a better meter indication and read on 30 MA scale, etc. (For computation of permissible condenser leakage, refer to basis noted previously.)

   CAUTION: AFTER THIS TEST IS COMPLETED, ALWAYS FIRST DISCONNECT THE NEGATIVE TEST LEAD FROM CIRCUIT BEFORE TURNING OFF POWER SUPPLY TO PREVENT SLAMMING OF METER POINTER DUE TO DISCHARGE OF CONDENSER UNDER TEST.

To test electrolytic condensers not incorporated in a radio set, an external D.C. power supply is necessary. Preferably one that employs various voltage taps suitable to application for the various D.C. voltage condenser ratings. In this case, adhere to the same testing procedure as noted above in paragraphs 1, 4 and 5, but making the following series connections:

a) Select voltage tap of D.C. power supply approximating rated voltage of condenser to be tested.
b) Connect positive potential of power supply to the positive "TEST" tip jack with a 4000 ohm limiting resistor in series if applied potential is above 100 volts. If potential is 100 volts or under, use a 900 ohm limiting resistor.
c) Connect negative potential of power supply to outside can or negative terminal of condenser.
d) Connect negative "TEST" tip jack to the (positive) anode terminal of condenser.
e) Refer to paragraphs 1, 4 and 5 for obtaining current leakage measurements.

QUALITATIVE PAPER CONDENSER TESTS:

The insulation resistance or permissible leakages of paper and mica condensers is expressed in megohm microfarads. A good 1 mfd. condenser will have an insulation

resistance of approximately 450 megohms. Furthermore, insulation resistance of paper and mica condensers of similar voltage ratings is inversely proportional to its capacity, so that a .1 mfd. condenser will have ten times the insulation resistance of a 1 mfd. condenser or 4500 megohms. It therefore can be readily seen that it is not readily practical to use the ohmmeter method for measuring leakages in paper or mica condensers, unless one has in his possession an exceptionally high reading megohmmeter (2000 megohms) such as is incorporated in "PRECISION" Series EV-10 Vacuum Tube Multi-Range Tester.

In the following method, a high D.C. potential is applied to the condenser in ies with the proper D.C. VOLTS range to determine whether or not it has low insulation istance or abnormal leakage.

The necessary D.C. potential can be obtained from an external high voltage D.C. power supply or from the power output tube socket of a radio receiver. In the latter instance, the plate prong position of that socket will be the positive high voltage lead and the negative return or ground will be the negative lead. Voltage to be applied to the condenser should be greater than its rated voltage.

PROCEDURE:

1. With "CIRCUIT SELECTOR" set to "D.C.-20,000 ohms per volt", measure the D.C. voltage obtainable from D.C. power supply to be used. Then select the proper voltmeter range that would indicate the greatest deflection for the voltage there available.

2. With the power supply OFF, insert the power supply output leads into the instrument tip jacks, observing correct polarities, and insert the condenser to be tested in series with one of these leads.

3. Turn ON power supply. An instantaneous deflection due to the charge of the condenser will be indicated on the D.C. meter.

a) In the case of a good condenser, the needle pointer will recede to the zero voltage mark.

b) If the meter pointer remains above the zero mark, then this indicates that the condenser has abnormal leakage.

c) If the meter pointer remains at the indicated value of the voltage measurement obtained initially, then the condenser is "shorted".

d) If no meter deflection is obtained, then this indicates that the condenser is "open" or that the capacity is too low in value to indicate an instantaneously noticeable meter deflection when charged.

CAUTION: AFTER THIS TEST IS COMPLETED, ALWAYS FIRST DISCONNECT THE NEGATIVE TEST LEAD FROM CIRCUIT BEFORE TURNING OFF POWER SUPPLY TO PREVENT SLAMMING OF NEEDLE POINTER DUE TO DISCHARGE OF CONDENSER UNDER TEST.

GENERAL INFORMATION

NOTE: A slight overload will damage or change characteristics of the meter rectifier incorporated. Rectifiers are checked carefully before the instrument leaves the factory. It is important to note this fact inasmuch as rectifiers are not guaranteed when overloaded.

Instructions and guarantee card are enclosed with this instrument. Mail the guarantee card at once for future information to be mailed from this record. Always give Pattern and Serial number when writfor information relative to this instrument.

SERIES 856 ACCESSORIES INCLUDED:

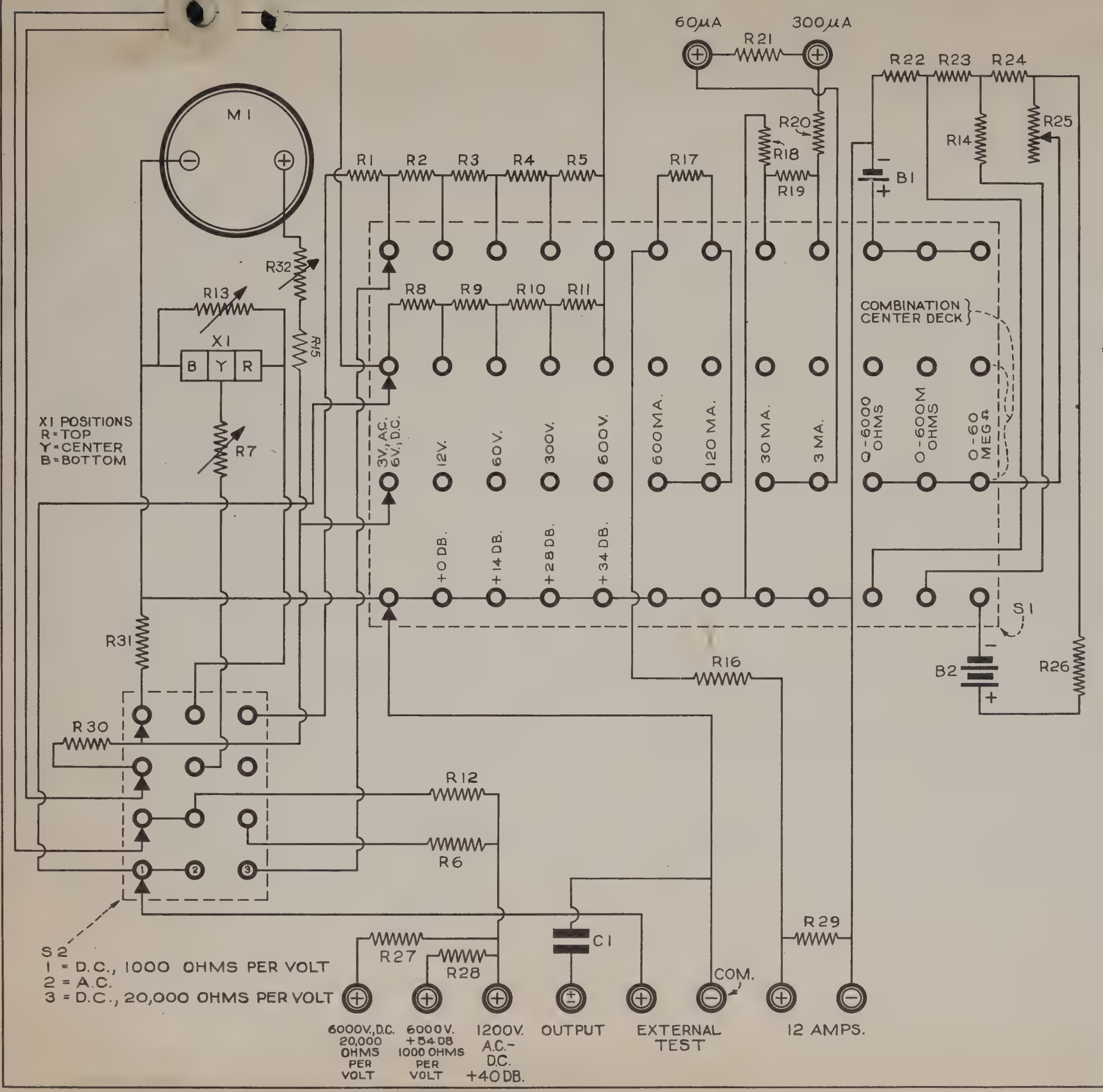
1	#950 1½ volt Eveready Battery	.10
1	#4156 22½ volt Burgess Battery	.55
1	Set extra high voltage Super-Flex test leads. Necessary for full safety of operation up to 6000 volts D.C. and 60 cycle A.C.(Part #228)	1.65

NOTE: Replacement batteries or "PRECISION" SUPER FLEX EXTRA HIGH VOLTAGE TEST LEADS can be purchased from your PRECISION DISTRIBUTOR, or from the factory upon receipt of money order or stamps equivalent to prices noted above.

* * * * *

PRECISION APPARATUS COMPANY
92-27 Horace Harding Blvd.
Elmhurst, L.I., N.Y.

DWG Nº 1032a


60µA
300µA
R21
R22
R23
R24
R25
R20
R18
R19
R14
B1
M1
R1
R2
R3
R4
R5
R17
R32
R13
X1
B
Y
R
R15
R8
R9
R10
R11
XI POSITIONS
R=TOP
Y=CENTER
B=BOTTOM
R7
3V, AC.
6V, D.C.
12V.
60V.
300V.
600V.
600 MA.
120 MA.
30 MA.
3 MA.
0-6000 OHMS
0-600M OHMS
0-60 MEG Ω
COMBINATION CENTER DECK
+0 DB.
+14 DB.
+28 DB.
+34 DB.
S1
R31
R16
B2
R26
R30
R12
R6
C1
R29
R27
R28
COM.
6000V.,D.C. 20,000 OHMS PER VOLT
6000V. +54 DB 1000 OHMS PER VOLT
1200V. A.C.-D.C. +40 DB.
OUTPUT
EXTERNAL TEST
12 AMPS.

S2
1 = D.C., 1000 OHMS PER VOLT
2 = A.C.
3 = D.C., 20,000 OHMS PER VOLT

NOTE:---R32---1000 ohm control calibrated to make sum of R-32 and resistance of M1 equal 2000 ohms. Used on 856-G ONLY.

*M1----50 microamps, 100 millivolts on Series 856.
50 microamps, calibrated to 100 millivolts with R32 on Series 856-G ONLY.

ITEM	PART NO.	SPECIFICATION
38	B2	22.5 VOLT BATTERY
37	B1	1.5 VOLT BATTERY
* 36	M1	50 MICROAMPS.
35	X1	RECTIFIER
34	S2	4 POLE 3 POSITION CIRUIT SELECTOR
33	S1	3 DECK RANGE SELECTOR (COMBINATION CENTER DECK)
32	C1	0.1 MFD. - 600 W.V.
31	R31	250 Ω (CALIBRATED)
30	R30	2750 Ω
29	R29	0.021 Ω
28	R28	4.8 MEG Ω
27	R27	96 MEG Ω
26	R26	344,120 Ω
25	R25	10 MΩ ADJUST OHMS
24	R24	18,180 Ω
23	R23	3,435 Ω
22	R22	34.7 Ω (CALIBRATED)
21	R21	20 MΩ
20	R20	4500 Ω
19	R19	450 Ω
18	R18	50 Ω
17	R17	1.667 Ω
16	R16	0.396 Ω
15	R15	3000 Ω
14	R14	420 Ω (CALIBRATED)
13	R13	1 MΩ SEALED (CALIBRATED)
12	R12	600 MΩ
11	R11	300 MΩ
10	R10	240 MΩ
9	R9	48 MΩ
8	R8	9 MΩ
7	R7	3 MΩ SEALED (CALIBRATED)
6	R6	12 MEG Ω
5	R5	6 MEG Ω
4	R4	4.8 MEG Ω
3	R3	960 MΩ
2	R2	180 MΩ
1	R1	55 MΩ

PRECISION APPARATUS CO.
ELMHURST, N.Y., U.S.A.

TITLE-SERIES 856 856-G SCHEMATIC

DRAWN BY DATE 9-25-43
CHECKED BY DATE 9-26-43

DECIBEL CONVERSION CHART

Power Level DB	Power Ratio to 0 DB	Power .006 Watt at 0 DB Watts	Voltage Ratio to 0 DB	Volts—Based on .006 Watt at 0 DB in	
				500 ohms	600 ohms
—10	0.1000	0.0006000	0.31623	0.5477	.6000
— 9	0.1259	0.0007553	0.35481	0.6145	.6732
— 8	0.1585	0.0009509	0.39811	0.6895	.7554
— 7	0.1995	0.0011972	0.44668	0.7737	.8475
— 6	0.2512	0.0015071	0.50119	0.8681	.9509
— 5	0.3162	0.0018975	0.56234	0.9740	1.0670
— 4	0.3981	0.0023886	0.63096	1.0928	1.1972
— 3	0.5012	0.0030071	0.70795	1.2262	1.3433
— 2	0.6310	0.0037857	0.79433	1.3758	1.5071
— 1	0.7943	0.0047660	0.89125	1.5437	1.6910
0	1.0000	0.0060000	1.00000	1.7321	1.8974
+ 1	1.2589	0.0075535	1.1220	1.9434	2.1289
+ 2	1.5849	0.0095093	1.2589	2.1805	2.3886
+ 3	1.9953	0.0119716	1.4125	2.4466	2.6801
+ 4	2.5119	0.0150713	1.5849	2.7451	3.0071
+ 5	3.1623	0.0189747	1.7783	3.0801	3.3741
+ 6	3.9811	0.0238865	1.9953	3.4559	3.7867
+ 7	5.0119	0.030071	2.2387	3.8776	4.2477
+ 8	6.3096	0.037857	2.5119	4.3507	4.7660
+ 9	7.9433	0.047660	2.8184	4.8816	5.3475
10	10.0000	0.060000	3.1623	5.4772	6.0000
11	12.589	0.075535	3.5481	6.1455	6.7321
12	15.849	0.095093	3.9811	6.8954	7.5536
13	19.953	0.119716	4.4668	7.7368	8.4752
14	25.119	0.150713	5.0119	8.6808	9.5094
15	31.623	0.189747	5.6234	9.7400	10.670
16	39.811	0.238865	6.3096	10.9285	11.972
17	50.119	0.30071	7.0795	12.2620	13.433
18	63.096	0.37857	7.9433	13.7582	15.071
19	79.433	0.47660	8.9125	15.4369	16.910
20	100.000	0.60000	10.0000	17.3205	18.974
21	125.89	0.75535	11.220	19.434	21.289
22	158.49	0.95093	12.589	21.805	23.886
23	199.53	1.19716	14.125	24.466	26.801
24	251.19	1.50713	15.849	27.451	30.071
25	316.23	1.89747	17.783	30.801	33.741
26	398.11	2.38865	19.953	34.559	37.867
27	501.19	3.0071	22.387	38.776	42.477
28	630.96	3.7857	25.119	43.507	47.660
29	794.33	4.7660	28.184	48.816	53.475
30	1000.00	6.0000	31.623	54.772	60.000
31	1258.9	7.5535	35.481	61.455	67.321
32	1584.9	9.5093	39.811	68.954	75.536
33	1995.3	11.9716	44.668	77.368	84.752
34	2511.9	15.0713	50.119	86.808	95.094
35	3162.3	18.9747	56.234	97.400	106.70
36	3981.1	23.8865	63.096	109.285	119.72
37	5011.9	30.071	70.795	122.620	134.33
38	6309.6	37.857	79.433	137.582	150.71
39	7943.3	47.660	89.125	154.369	169.10
40	10000.0	60.000	100.000	173.205	189.74
41	12589.2	75.535	112.20	194.34	212.89
42	15848.9	95.093	125.89	218.05	238.86
43	19952.6	119.716	141.25	244.66	268.01
44	25118.9	150.713	158.49	274.51	300.71
45	31622.8	189.747	177.83	308.01	337.41
46	39810.7	238.865	199.53	345.59	378.67
47	50118.7	300.71	223.87	387.76	424.77
48	63095.7	378.57	251.19	435.07	476.60
49	79432.7	476.60	281.84	488.16	534.75
50	100000.0	600.00	316.25	547.72	600.00

PRECISION APPARATUS COMPANY

Manufacturers of Fine Electrical Test Equipment

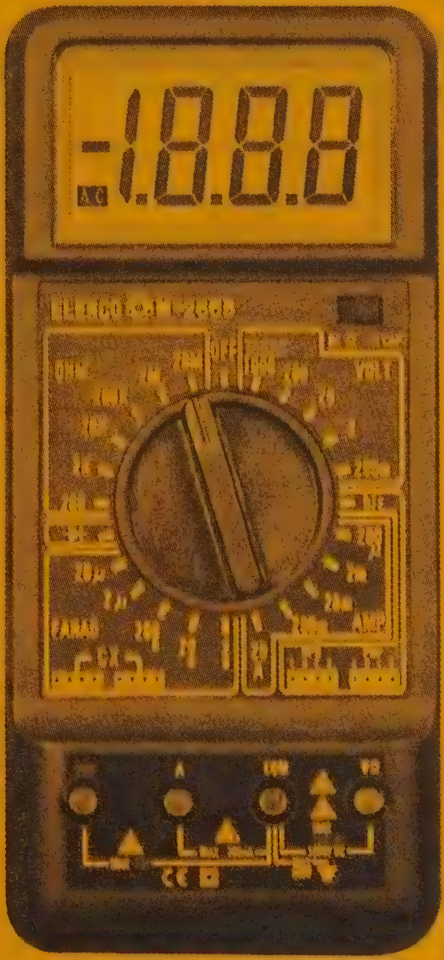
NOT

USED ON
WEB —
TOO
RECENT!

DIGITAL MULTIMETER KIT

MODEL M-2665K

WIDE RANGE DIGITAL MULTIMETER WITH CAPACITANCE AND TRANSISTOR TESTING FEATURES



Assembly and Instruction Manual

OMNITRON ELECTRONICS

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INTRODUCTION

Assembly of your M-2665 Digital Multimeter Kit will prove to be an exciting project and give much satisfaction and personal achievement. If you have experience in soldering and wiring technique, you should have no problems. For the beginner, care must be given to identifying the proper components and in good soldering habits. Above all, take your time and follow the easy step-by-step instructions. Remember, "An ounce of prevention is worth a pound of cure".

The meter kit has been divided into a number of sections to make the assembly easy and avoid major problems with the meter operation.
Section A - Meter display circuit assembly.
Section B - DC voltage and current circuit assembly.
Section C - AC voltage and current circuit assembly.
Section D - Resistance circuit assembly.
Section E - Capacitance and transistor testing circuit assembly.
Section F - Final assembly.

THEORY OF OPERATION

A block diagram of the M-2665K is shown in Figure 1. Operation centers around a custom LSI chip. This IC contains a dual slope A/D converter display latches decoder and the display driver. A block diagram of the IC functions is shown in Figure 6. The input voltage, current or ohm signals are conditioned by the function and selector switches to produce and output DC voltage between 0 and +199mV. If the input signal if 100VDC, it is reduced to 100mV DC by selecting a 1000:1 divider. Should the input be 100V DC, then after the divider it is processed by the AC converter to produce 100mV DC. If current is to be read, it is converted to a DC voltage via internal shunt resistors. For resistance measurements, an internal voltage source supplies the necessary 0-199mV voltage to be fed to the IC input.

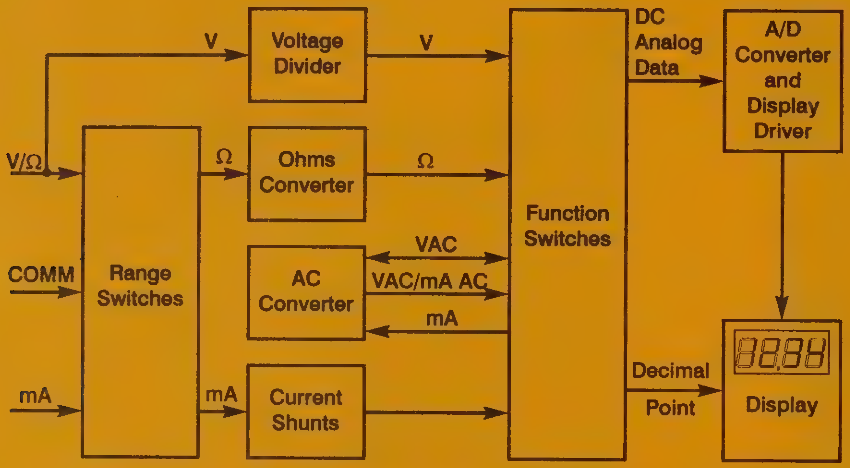


Figure 1 Simplified Block Diagram

The input of the 7106 IC is fed to an A/D (analog to digital) converter. Here the DC voltage amplitude is changed into a digital format. The resulting signals are processed in the decoders to light the appropriate LCD segment.

Timing for the overall operation of the A/D converter is derived from an external oscillator whose frequency is selected to be 40KHz. In the IC, this frequency is divided by four before it clocks the decade counters. It is further divided to form the three convert-cycle phases. The final readout is clocked at about three readings per second.

Digitized measurements data is presented to the display as four decoded digits (seven segments) plus polarity. Decimal point position on the display is determined by the selector switch setting.

☐ Mount the two 9-pin component sockets to the PC board with the notch at the base of the socket in the direction shown in Figure L. Solder the sockets in place from the top legend side.

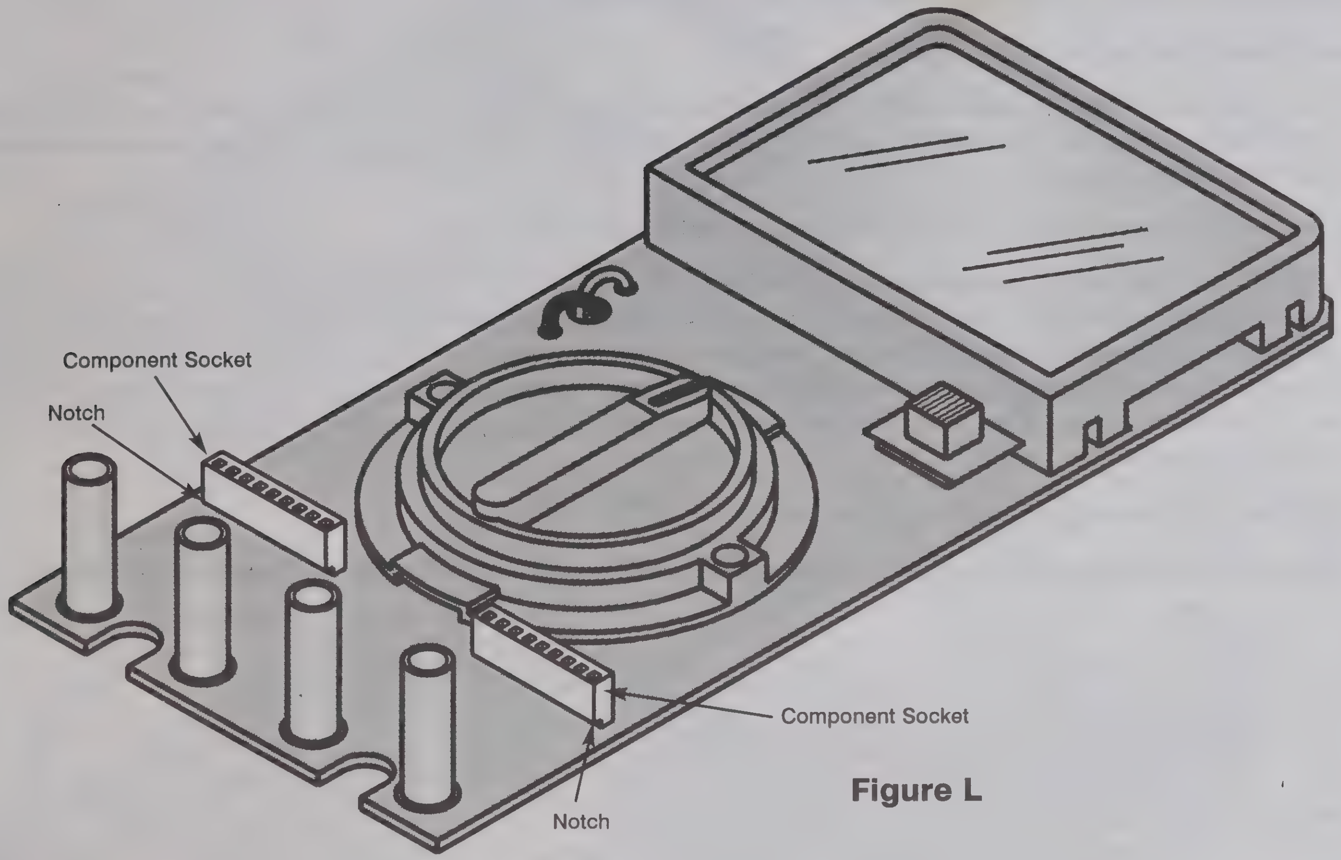
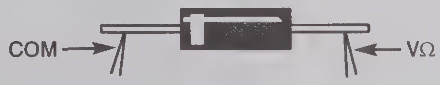


Figure L

Testing Procedure

Connect the 9V battery and test leads to the meter (red to VΩ and black to COM). Set the range selector knob to the diode scale and set SW1 in the DC Ohm position. Connect a diode to the test leads with the correct polarity (see figure below). The meter will range for 100 - 950. If the tests are not working, check for cold solder joints and part values. Turn the meter off and remove the battery and test leads. **DO NOT PROCEED TO SECTION F WITHOUT THE INSTRUCTOR'S APPROVAL.**



SECTION F

Final Assembly

PARTS LIST - SECTION F

Qty	Description	Part #	Qty	Description	Part #
☐ 1	Battery Cushion	620001	☐ 1	Shield Spring	680008
☐ 1	Top Case	623101A	☐ 2	Knob Spring	680009
☐ 1	Bottom Case w/Stand	623200A	☐ 1	Top Plate (B)	724000A
☐ 3	Screw M2.3 x 6	642360	☐ 1	Shield	780008
☐ 2	Screw M3 x 12	642367	☐ 1	Grease	790004
☐ 2	Bearing	666001			

Note: The shield and battery cushion may be installed already.

FINAL ASSEMBLY

☐ Solder the spring to the PC board as shown in Figure Ma.

See Figure N for the following steps.

☐ Peel off the protective backing on the top plates (A) and (B) and stick them to the top case. Peel off the protective backing on the battery cushion and stick it onto the bottom case. **(These may be installed on the case already)**.

☐ Turn the selector knob screw one full turn out as shown in the figure.

☐ Place the PC board on a standard piece of paper (8 1/2" x 11"). Insert the two springs into the holes on the range selector knob. Put grease on top of the springs and then place a ball bearing on each spring. Press the top case onto the PC board. Using both hands, slide your fingers under the paper. Press your thumbs down on the top case and then flip the board. Be sure to hold the PC board to the case firmly or the ball bearings will fall out. Fasten the PC board to the top case with three M2.3 x 6 screws in the places shown in Figure M.

☐ Connect the battery and place it in the cavity of the top case.

☐ Place the bottom case onto the top case. Hold the two sections together with two M3 x 12 screws.

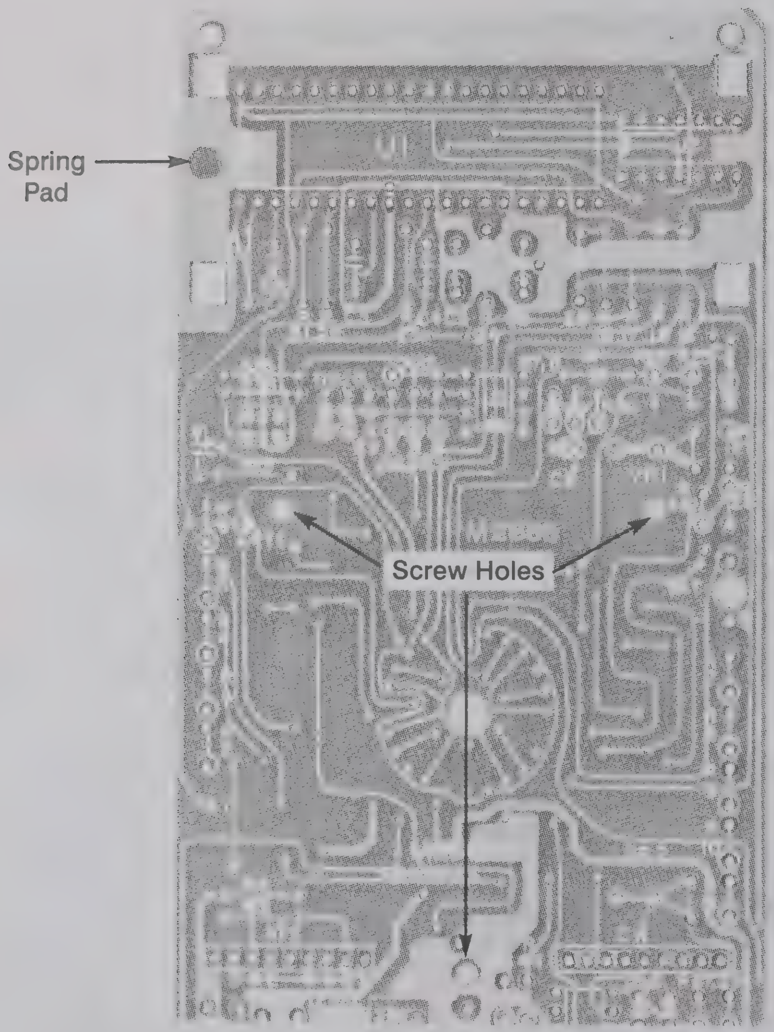


Figure M

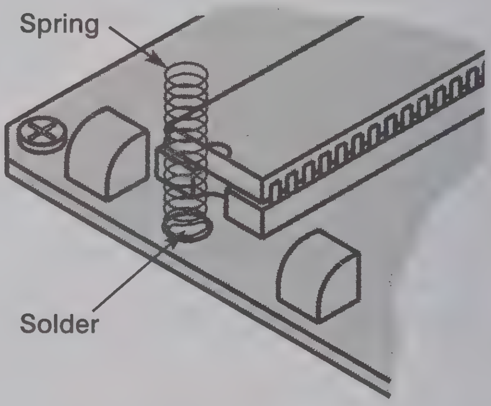


Figure Ma

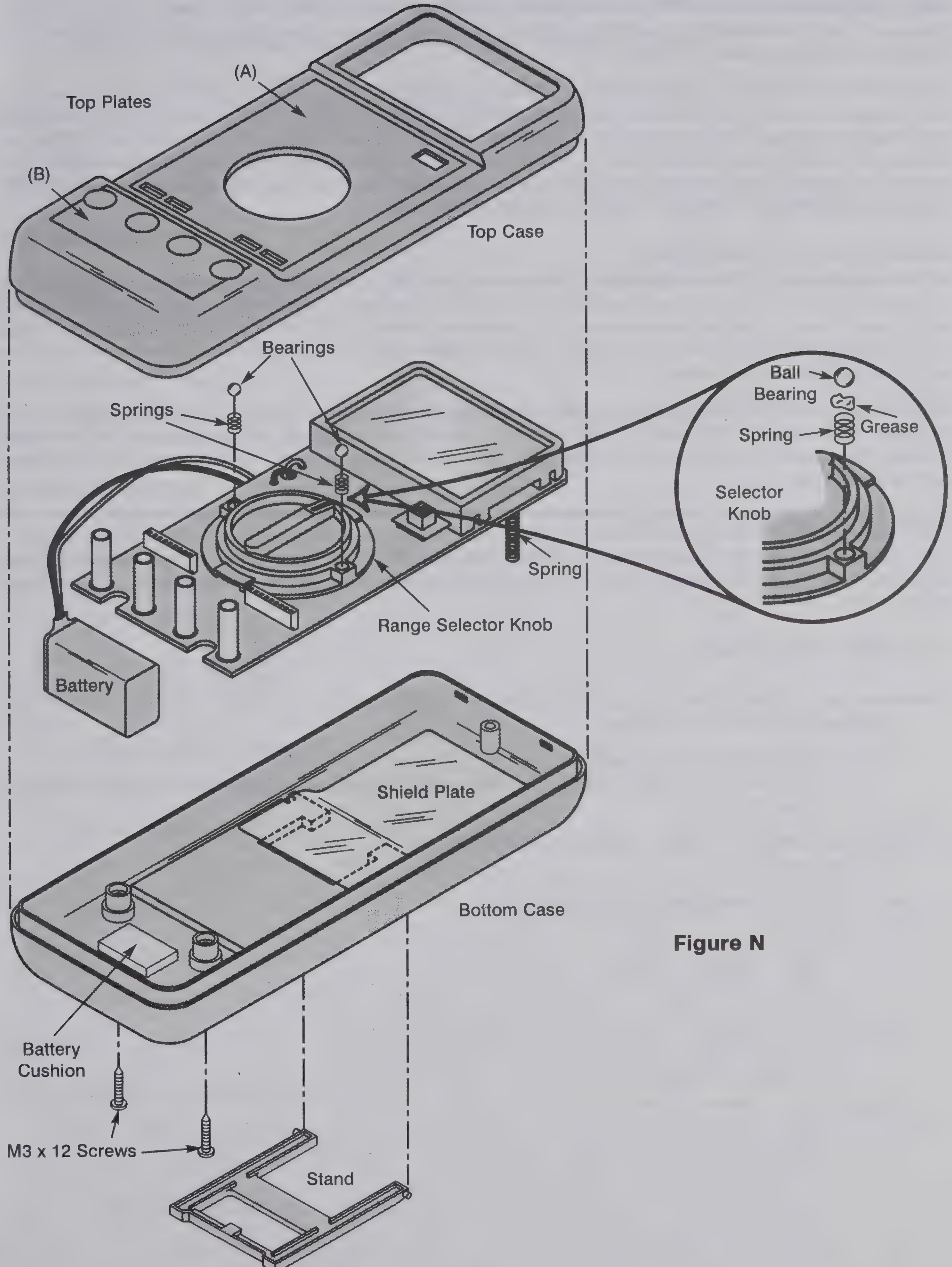

(A)
Top Plates
(B)
Top Case
Bearings
Springs
Ball Bearing
Grease
Spring
Selector Knob
Spring
Range Selector Knob
Battery
Shield Plate
Bottom Case
Battery Cushion
M3 x 12 Screws
Stand

Figure N

Testing Procedure SECTION C - AC voltage and current circuit

Measure an AC voltage with a known accurate meter. Now measure the voltage with the kit meter. The meters should be the same voltage.

Connect the kit meter and another meter of known accuracy in series. Set the meters in the 200mA position. Construct a circuit for an AC current and measure the circuit current. Both meters should have close to the same readings. If the meters do not agree, check the parts just added. Do not re-adjust VR1 this will change the voltage reading set in step 1. Check the 200µ - 200mA scales. The 20A scale requires, a circuit of 1 - 10 amps. If the tests are not working, check for cold solder joints and part values. **DO NOT PROCEED TO SECTION F WITHOUT INSTRUCTORS APPROVAL.**

Testing Procedure SECTION F

Set the meter in one of the farad scales. Make sure that SW1 is in the AC/Cap position. Measure a cap with another meter and then insert the same cap into the kit meters CX connectors. Adjust VR2 so that the meter reads the same as the accurate one. This calibrates capacitance circuit of meter. Using two or three different value capacitors, check each scale. Compare the kit meter readings with another meter. Turn the meter off and remove the battery.

Set the meter in the h_{FE} scales. Place an NPN transistor into the socket. Make sure that the transistor is in correctly. Depending on the type of transistor, the meter will range from 20 to 550. Place a PNP transistor into the PNP socket, the range will also be 20 to 550. If the tests are not working, check for cold solder joints and part values.

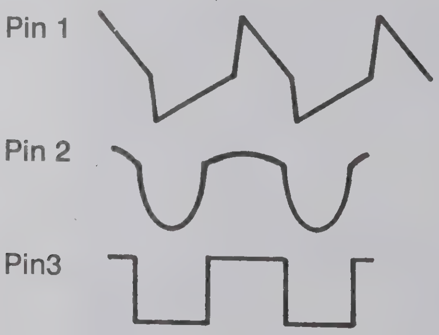
TROUBLESHOOTING GUIDE

If the meter is not working, perform the U1 (7106R) Voltage Test first. This test is to verify that the IC and Reference Voltage are operational. Then perform the tests that pertain to the Function that is not working on your meter.

U1 (7106R) Voltage Test

1. Measure the voltage across pin 40 and pin 15 on U1 (7106R) for 9V.
    A. Check the battery connection.

    B. Check for a 9V and GND short.
        1. One of the ICs may be bad. Remove one IC at a time and check voltage again between pin 40 - 15.
2. Measure the voltage across pin 40 and pin 9 on U1 for 3V.
    A. U1 is defective.
3. Check the Main Oscillator on U1 (7106R) pins 1, 2, 3.



4. Measure the voltage across pin 5 and pin 6 on U1 (7106R) for 70mV - 105mV (reference voltage).
    - A. Adjust VR1 so the the junction of R46, R27 and R28 equal to 100mV.
        - 1. Can't set to 100mV.
            - a. VR1 wrong value or defective.
            - b. R25, R27 and R28 wrong value.
    - B. Can't obtain 100mV between pin 5 and pin 6.
        - 1. Check R21 and R46.

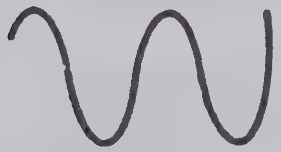
Voltage/OHM Section

1. Measure across V OHM terminal and COM terminal for 10MΩ (set meter in 200mV) battery installed.
    - A. Lower or higher than 10MΩ.
        - 1. Check resistors R1 - R6.
2. LCD readings floating.
    - A. Measure across the COM terminal to pin 6 on U1 (7106R) for 1MΩ.
        - 1. R22 open or defective.

AC Voltage Section

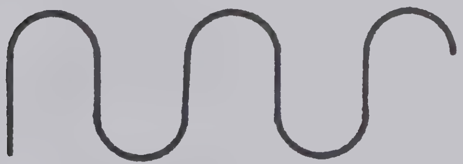
1. Apply 15VAC to meter and measure pin 1 and pin 7 of U3 (358) to COM terminal with a scope (meter on 20VAC scale).

    Pin 1 to COM .44Vpp

    - A. Check DC/AC switch
    - B. Check C7, R29 - R32, D7, D8 and U3.

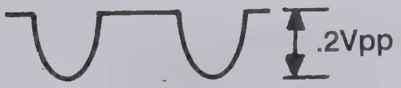
    Pin 7 to COM 1.4Vpp

    - A. Check R33 - R36, D9, D10, C9 and U3.

2. Check pin 10 and pin 11 of U1 (7106R) with a scope.

    Waveform on pin 10 and pin 11.

    - A. Check C4 and R23.

Amps Section

1. 200mA scale not working:
    A. Check fuse.

    B. Measure across (A) terminal and (COM) terminal for 1Ω (set meter in 200mA).
        1. Lower or higher than 1Ω, Check R13.

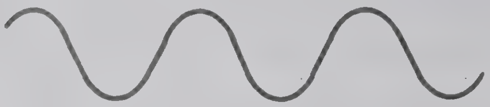
2. 20mA scale not working:
    A. Check fuse.

    B. Measure between (A) terminal and (COM) for 10Ω (set meter in 20mA).
        1. Lower or higher than 10Ω, check R12 and R13.

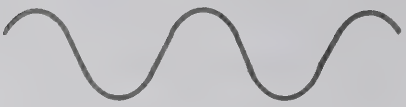
Capacitance Section

1. Place .001μF cap in the socket and check pin 7 and pin 8 of U4 with a scope (meter set to 2N).

Pin 7 370Hz - 400Hz .12Vpp.



Pin 14 370Hz - 400Hz .3Vpp.



A. No signal at pin 14.
    1. Check D3, D4 and shorts.

B. No signal at pin 7 but present at pin 1.
    1. Check D5 and D6.

h_{FE} Section

1. Check for shorts on socket pins.

2. Measure across B terminal to COM terminal for 251KΩ.
    A. Lower or higher than 251KΩ; Check R14 and R15.

Decimal Point Section

1. Displays two decimal points.
    A. Shorted output on U2.

2. No decimal points displayed.
    A. Check U2 325.

Diode

1. Measure voltage across V OHM and COM terminal (set in diode mode) = 1.3V.
    A. Low voltage, check R26.

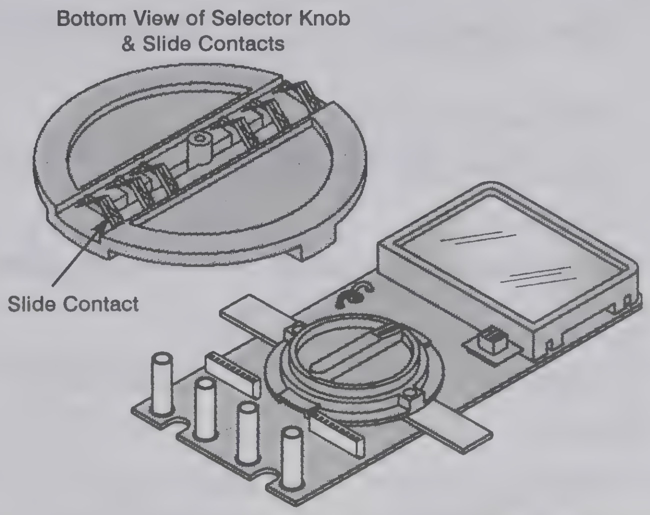
Battery Low Indicator

1. Not working.
    A. Check ZD1, R19 and U2.

REINSTALLATION OF THE RANGE SELECTOR KNOB

If you removed the range selector knob for troubleshooting, then follow the instructions below to reinstall it.

Place the PC board over the range selector knob and fasten the knob to the PC board with a M2.3 x 8 screw. **CAUTION:** Do not overtighten the screw. The knob should be snug, but not loose. Turn back the M2.3 x 8 screw 1/2 turn. Slip the two shims under the knob (see Figure O). If they do not slip in, turn back the screw another 1/4 turn. Tighten the screw just enough so that the shims can be pulled out. You should now have the proper tension to hold the knob and contacts in place and rotate the knob to the desired positions.



USING THE DIGITAL MULTIMETER

Familiarize yourself with your new digital meter by taking readings of known resistances and voltages. You will find that the readings will not be as accurate on certain ranges for a given measurement. For example, when measuring a low resistance on a high range, the reading will show a short 0.00. When measuring a high resistance on a low range, the reading will show infinity 1. Likewise, it is important to use the correct range when measuring voltages.

Table 1 shows an example of the readouts for different values of resistance. Table 2 shows an example of the readouts for 117V AC and 100V DC. The shaded area indicates the most accurate range. It must be remembered that the readings will shift slightly when switching to a different range.

MEASURED RESISTANCE	← RANGE SETTING →					
	200Ω	2KΩ	20KΩ	200KΩ	2MΩ	20MΩ
SHORT (LEADS TOUCHING)	* 00.1	.000	0.00	00.0	.000	0.00
INFINITY	1 .	1.	1 .	1 .	1.	1 .
47Ω	52.1	.052	0.05	00.0	.000	0.00
270Ω	1 .	.267	0.26	00.2	.000	0.00
10KΩ	1 .	1.	10.18	10.2	.010	0.01
47KΩ	1 .	1.	1 .	52.7	.052	0.05
470KΩ	1 .	1.	1 .	1 .	.472	0.47
2.2MΩ	1 .	1.	1 .	1 .	1.	2.12

* RESISTANCE OF TEST LEADS

Table 1

Table 2

MEASURED VOLTAGE	200mV	2V	20V	200V	1000V
117VAC	1 .	1.	1 .	117.0	117
100VDC	1 .	1.	1 .	100.0	100

1. FEATURES

- Wide measuring ranges: 34 ranges for AC/DC Voltage and Current, Resistance, Capacitance, TR hFE, Diode Test.
- 10MΩ Input Impedance
- Big LCD for easy reading
- Tilt Stand

2. SPECIFICATIONS

2-1 General Specifications

Display	3 1/2 LCD 0.95” height, maximum reading of 1999.
Polarity	Automatic “--” sign for negative polarity.
Overrange Indication	Highest digit of “1” or “--1” is displayed.
Low Battery Indication	“BAT” lettering on the LCD readout.
Operating Temperature	0°C to 50°C. less than 80% relative humidity up to 35°C. less than 70% relative humidity from 35°C to 50°C.
Storage Temperature	--15°C to 50°C
Temperature Coefficient	0°C to 18°C and 28°C to 50°C. less than 0.1 x applicable accuracy specification per degree C.
Power	9V alkaline or carbon zinc battery (NEDA 1604).
Battery Life (typical)	100 hours with carbon zinc cells. 200 hours with alkaline cells.
Dimensions	88 (W) x 191 (L) x 36 (H) m/m.
Weight	Approximately 300g.
Accessories	Safety Test Lead 1 pair

2-2 Measurement Ranges (Accuracy: 1 year 18°C to 28°C)

DC Voltage

Range	Resolution	Accuracy	Maximum Input
200mV	100μV	±0.5% of rdg ± 2dgt	DC 1000V or peak AC
2V	1mV	±0.5% of rdg ± 2dgt	
20V	10mV	±0.5% of rdg ± 2dgt	
200V	100mV	±0.5% of rdg ± 2dgt	
1000V	1V	±0.5% of rdg ± 2dgt	

Normal Mode Rejection Ratio: Greater than 46dB at 50Hz 60Hz (1K unbalance)

AC Voltage

Range	Resolution	Accuracy	Maximum Input
200mV	100µV	±1.2% of rdg ± 2dgt	AC 750V maximum 50Hz - 400Hz
2V	1mV	±1.2% of rdg ± 2dgt	
20V	10mV	±1.2% of rdg ± 2dgt	
200V	100mV	±1.2% of rdg ± 2dgt	
750V	1V	±1.2% of rdg ± 2dgt	

Resistance

Range	Resolution	Accuracy	Test Current	Input Protection
200Ω	0.1Ω	±0.8% of rdg ± 2dgt	Approximately 1.2mA	Protected By PTC
2KΩ	1Ω	±0.8% of rdg ± 2dgt		
20KΩ	10Ω	±0.8% of rdg ± 2dgt		
200KΩ	100Ω	±0.8% of rdg ± 2dgt		
2MΩ	1KΩ	±1.0% of rdg ± 3dgt		
20MΩ	10KΩ	±3.0% of rdg ± 4dgt		

Maximum open circuit voltage: 2.8V

DC Current

Range	Resolution	Accuracy	Protection
200µA	100nA	±0.5% of rdg ± 2dgt	Protected by 250V/2A Fuse
2mA	1µA	±0.5% of rdg ± 2dgt	
20mA	10µA	±0.5% of rdg ± 2dgt	
200mA	100µA	±0.5% of rdg ± 2dgt	
20A	10mA	±1.0% of rdg ± 3dgt	

AC Current

Range	Resolution	Accuracy	Protection
200µA	100nA	±1.2% of rdg ± 3dgt	Protected by 250V/2A Fuse
2mA	1µA	±1.2% of rdg ± 3dgt	
20mA	10µA	±1.2% of rdg ± 3dgt	
200mA	100µA	±1.2% of rdg ± 3dgt	
20A	10mA	±3.0% of rdg ± 3dgt	

Capacitance

Range	Resolution	Accuracy	Protection
2nF	1pF	±3.0% of rdg ± 3dgt	Test frequency 400Hz±3.0% Test Voltage 120mV
2nF	10pF	±3.0% of rdg ± 3dgt	
200nF	100pF	±3.0% of rdg ± 3dgt	
2µF	1nF	±3.0% of rdg ± 3dgt	
20µF	10nF	±3.0% of rdg ± 3dgt	

Transistor h_{FE}

Range	Test Condition
NPN	10mA 2.8V
PNP	10mA 2.8V

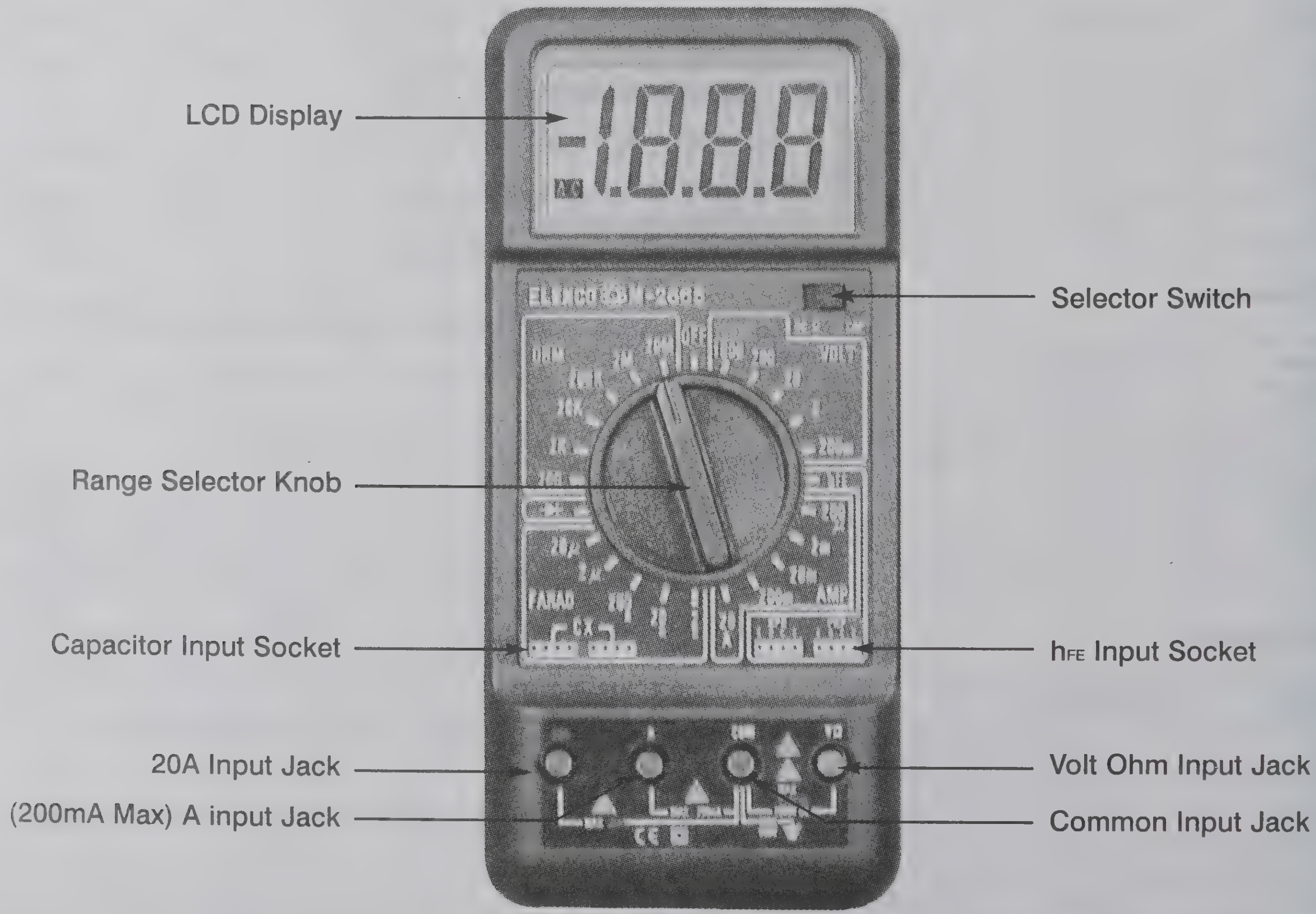
Diode Test
Measures forward resistance of a semiconductor junction in K Ohm at max. test current of 1.5mA.

3. OPERATION

3-1 Preparation and caution before measurement

1. If the function must be switched during a measurement, always remove the test leads from the circuit being measured.
2. If the unit is used near noise generating equipment, be aware that the display may become unstable or indicate large errors.
3. Avoid using the unit in places with rapid temperature variations.
4. In order to prevent damage or injury to the unit, never fail to keep the maximum tolerable voltage and current, especially for the 20A current range.
5. Carefully inspect the test lead. If damaged, discard and replace.

3-2 Panel Description


LCD Display
Selector Switch
Range Selector Knob
Capacitor Input Socket
hFE Input Socket
20A Input Jack
Volt Ohm Input Jack
(200mA Max) A input Jack
Common Input Jack

3-3 Method of Measurement

(A) DC/AC Voltage Measurement

1. Set the selector switch to "DC" or "AC".
2. Connect the red test lead to "V/Ω" input jack and the black one to the "COM" jack.
3. Set the range selector knob to the desired volt position. If the magnitude of the voltage is not known, set the range selector knob to the highest range and reduce until a satisfactory reading is obtained.
4. Connect the test leads to the device or circuit being measured.
5. Turn on the power to the device or circuit being measured. The voltage value will appear on the digital display along with the voltage polarity.
6. Turn off the power to the device or circuit being tested and discharge all of the capacitors prior to disconnecting the test leads.

(B) DC/AC Current Measurement

1. Set the selector switch to "DC" or "AC".
2. Connect the red test lead to the "A" input jack for current measurement up to 200mA, and the black one to "COM".
3. Set the range selector knob to the desired "Amp" current position.

   If the magnitude of current is not known, set the rotary/function switch to the highest range and reduce until a satisfactory reading is obtained.
4. Open the circuit to be measured, and connect the test leads in series with the load in which current is to be measured.
5. Read the current value on the digital display.
6. Turn off all power to the circuit being tested and discharge all of the capacitor prior to disconnecting the test lead.
7. To measure in the 20A range, use the "20A" jack as the input jack. Be sure to measure within 10 seconds to avoid high-current hazard.

(C) Resistance Measurement

1. Set the selector switch to the "Ohm" position.
2. Connect red test lead to the "V/Ω" input jack and the black one to "COM".
3. Set the range selector knob to desired "Ohm" position.
4. If the resistance being measured is connected to a circuit, turn off the power to the circuit being tested and discharge all capacitors.
5. Connect the test leads to the circuit being measured. When measuring high resistance, be sure not to contact adjacent point even if insulated, because some insulators have a relatively low insulation resistance, causing the measured resistance to be lower than the actual resistance.
6. Read resistance value on digital display.

(D) Diode Test

1. Set the selector switch to the “Ohm” position.
2. Connect the red test lead to “V/Ω” input jack and the black one to the “COM” jack.
3. Set the range selector knob to the “ —▶|— ” position.
4. If the semiconductor junction being measured is connected to the circuit, turn off the power to the circuit being tested and discharge all of the capacitors.
5. Connect the test leads to the device and read forward value on the digital display.
6. If the digital reads overrange (1), reverse the lead connections.

   The placement of the test leads when the forward reading is displayed indicates the orientation of the diode.

   The red lead is positive and the black lead is negative.

   If overrange (1) is displayed with both lead connections, the junction is open.

(E) Transistor h_{FE} Measurement

1. Set the selector switch to “DC”.
2. The transistor must be out of circuit. Set the rotary/function switch to the h_{FE} position.
3. Plug the emitter, base and collector leads of the transistor into the correct holes in either the NPN of the PNP transistor test socket, whichever is appropriate for the transistor you are checking.
4. Read the h_{FE} (beta or DC current gain) on the display.

(F) Capacitance Measurement

1. Set the range selector knob to the “FARAD” position.
2. Set the range selector knob to the desired capacitance position.
3. Short the leads of the capacitor to be tested together to insure that there is no charge on the capacitor.
4. Insert the capacitor leads into the capacitor test socket. Note that there are two groups of holes. One lead must be inserted into one of group one, and the other lead must be inserted into one of the holes of group two.
5. Read the capacitance value on the digital display.

4. OPERATION MAINTENANCE

4-1 Battery and Fuse Replacement

CAUTION

BEFORE ATTEMPTING BATTERY REMOVAL OR REPLACEMENT, DISCONNECT THE TEST LEADS FROM ANY ENERGIZED CIRCUITS TO AVOID SHOCK HAZARD.

The fuse rarely needs replacement and blow almost always as a result of operator error. To replace the battery and fuse (2A/250V), remove the two screws in the bottom of the case. Simply remove the old battery or fuse and replace with a new one.

Be sure to observe the polarity when replacing the battery.

4-2 Calibration Procedure

It is normally not necessary to recalibrate for long intervals. If needed, adjustment should be done with highly accurate standards (setter than 0.1% accuracy).

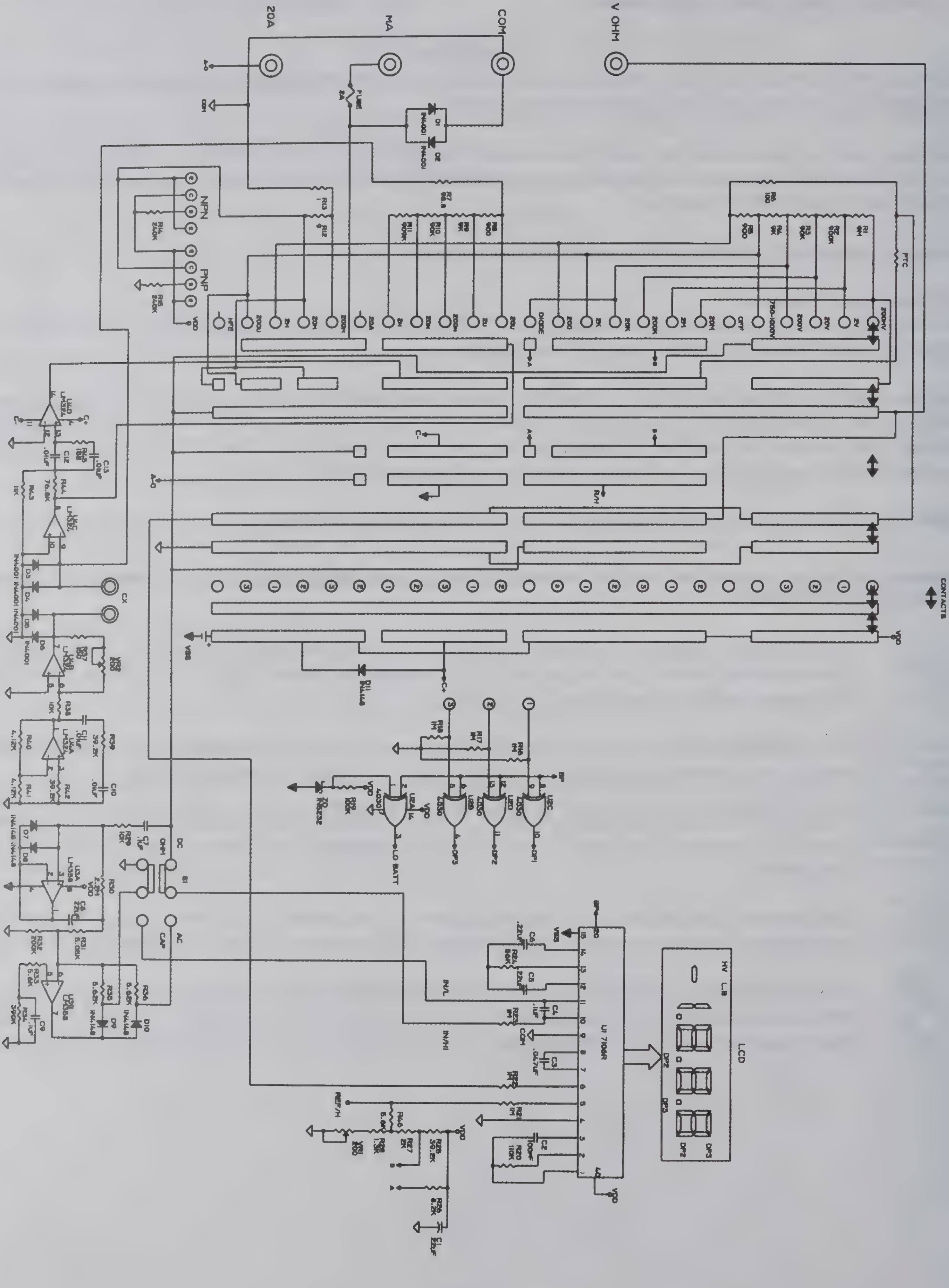
Remove the two phillips head screws. Carefully remove the plastic back cover. With the instrument operating and set to the 200mV DC range (20μF capacitance range), apply 190mV DC (10μF) from an accurate source. With a small screwdriver inserted into the semi-fixed resistor VR1 (VR2: Capacitance), carefully turn the variable resistor into the reading until the reading reads 190mV (10μF).

NOTE: Be sure to proceed basic calibration by DC range first prior to capacitance.

5. SAFETY SYMBOLS

⚠	This marking adjacent to another marking or a terminal operating device indicates that the operator must refer to an explanation in the operating instructions to avoid damage to the equipment and/or to avoid personal injury.
WARNING	This WARNING sign denotes a hazard. It calls attention to a procedure, practice or the like, which if not correctly performed or adhered to, could result in personal injury.
CAUTION	This CAUTION sign denotes a hazard. It calls attention to a procedure, practice or the like, which if not correctly adhered to, could result in damage to or destruction of part or all of the instrument.
⏚ 500V max.	This marking advises the user that the terminal(s) so marked must not be connected to a circuit point at which the voltage, with respect to earth ground, exceeds (in this case) 500 volts.
⚡	This symbol adjacent to one or more terminals identifies them as being associated with ranges that may in normal use be subjected to particularly hazardous voltages. For maximum safety, the instrument and its test leads should not be handled when these terminals are energized.

SCHEMATIC DIAGRAM


20A
MA
COM
V OHM
FUSE 2A
D1 1N4001
D2 1N4001
NPN
PNP
PTC
CONTACTS
CX
DC
OHM
AC
CAP
LO BATT
DP1
DP2
DP3
U1 7106R
LCD
HV
LB
REF/H
VDD
VSS
BP
IN/L
IN/HI
COM

A/D CONVERTER

A simplified circuit diagram of the analog portion of the A/D converter is shown in Figure 2. Each of the switches shown represent analog gates which are operated by the digital section of the A/D converter. Basic timing for switch operation is keyed by an external oscillator. The conversion process is continuously repeated. A complete cycle is shown in Figure 2.

Any given measurement cycle performed by the A/D converter can be divided into three consecutive time periods: autozero (AZ), integrate (INTEG) and read. Both autozero and integrate are fixed time periods. A counter determines the length of both time periods by providing an overflow at the end of every 1000 clock pulses. The read period is a variable time, which is proportional to the unknown input voltage. The value of the voltage is determined by counting the number of clock pulses that occur during the read period.

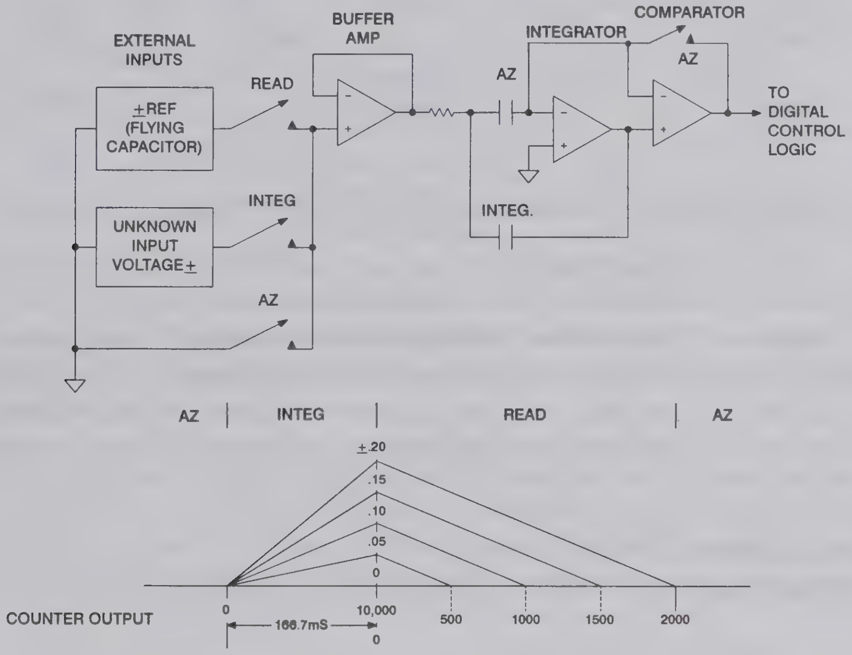


Figure 2 Dual Slope A/D Converter

During autozero, a ground reference is applied as an input to the A/D converter. Under ideal conditions the output of the comparator would also go to zero. However, input-offset-voltage errors accumulate in the amplifier loop, and appear at the comparator output as an error voltage. This error is impressed across the AZ capacitor where it is stored for the remainder of the measurement cycle. The stored level is used to provide offset voltage correction during the integrate and read periods.

The integrate period begins at the end of the autozero period. As the period begins, the AZ switch opens and the INTEG switch closes. This applies the unknown input voltage to the input of the A/D converter. The voltage is buffered and passed on to the unknown input voltage to the input of the A/D converter. The voltage is buffered and passed on to the integrator to determine the charge rate (slope) on the INTEG capacitor. At the end of the fixed integrate period, the capacitor is charged to a level proportional to the unknown input voltage. This voltage is translated to a digital indication by discharging the capacitor at a fixed rate during the read period, and counting the number of clock pulses that occur before it returns to the original autozero level.

As the read period begins, the INTEG switch opens and the read switch closes. This applies a known reference voltage to the input of the A/D converter. The polarity of this voltage is automatically selected to be opposite that of unknown input voltage, thus causing the INTEG capacitor to discharge as fixed rate (slope). When the charge is equal to the initial starting point (autozero level), the read period is ended. Since the discharge slope is fixed during the read period, the time required is proportional to the unknown input voltage.

The autozero period and thus a new measurement cycle begins at the end of the read period. At the same time, the counter is released for operation by transferring its contents (previous measurement value) to a series of latches. This stored stat is then decoded and buffered before being used for driving the LCD display.

VOLTAGE MEASUREMENT

Figure 3 shows a simplified diagram of the voltage measurement function.

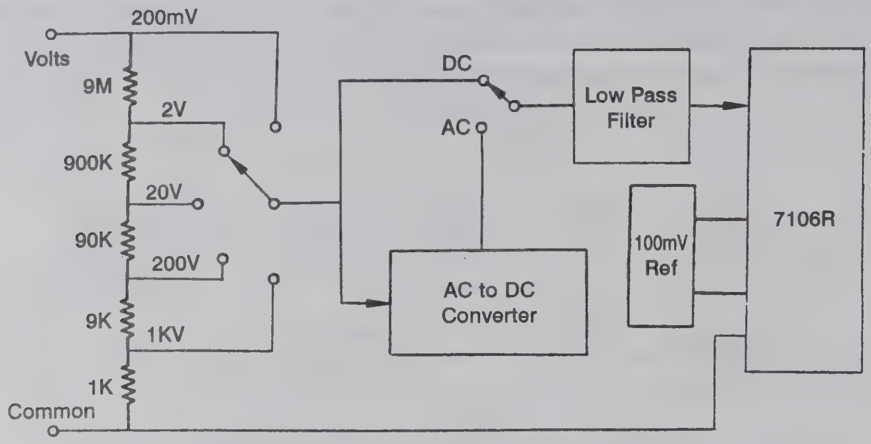

200mV
Volts
9M
2V
900K
20V
90K
200V
9K
1KV
1K
Common
DC
AC
Low Pass Filter
100mV Ref
7106R
AC to DC Converter

Figure 3 Simplified Voltage Measurement Diagram

The input divider resistors add up 10MΩ with each step being a division of 10. The divider output should be withing -0.199 to +0.199V or the overload indicator will function. If the AC function is selected, the divider output is AC coupled to a full wave rectifier and the DC output is calibrated to equal the RMS level of the AC input.

CURRENT MEASUREMENT

Figure 4 shows a simplified diagram of the current measurement positions.

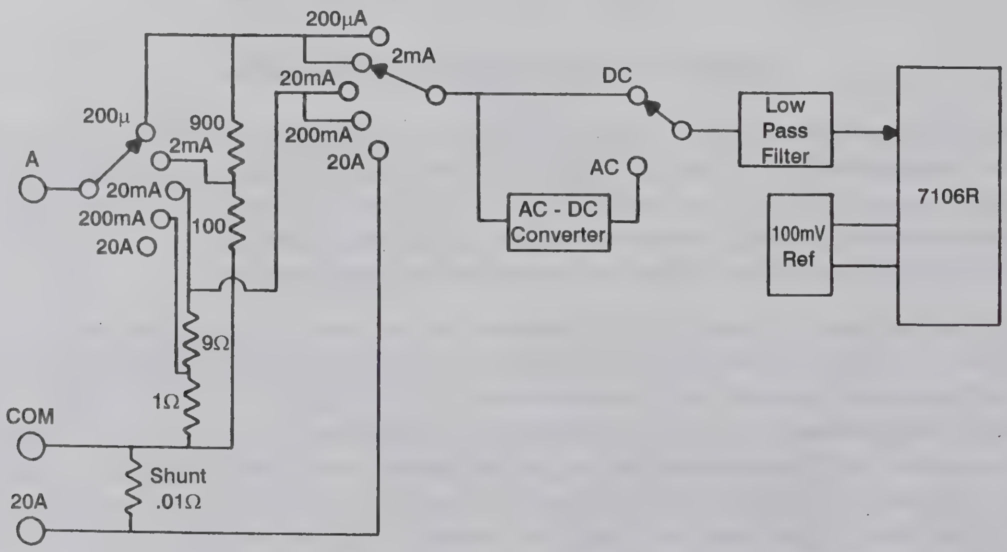

200μA
2mA
20mA
200mA
20A
DC
AC
Low Pass Filter
7106R
100mV Ref
AC - DC Converter
200μ
2mA
A
20mA
200mA
20A
900
100
9Ω
1Ω
COM
Shunt .01Ω
20A

Figure 4 Simplified Current Measurement Diagram

Internal shunt resistors convert the current to between -0.199 to +0.199V which is then processed in the 7106 IC to light the appropriate LCD segments. If the current is AC in nature, the AC converter changes it to the equivalent DC value.

RESISTANCE MEASUREMENTS

Figure 5 shows a simplified diagram of the resistance measurement function.

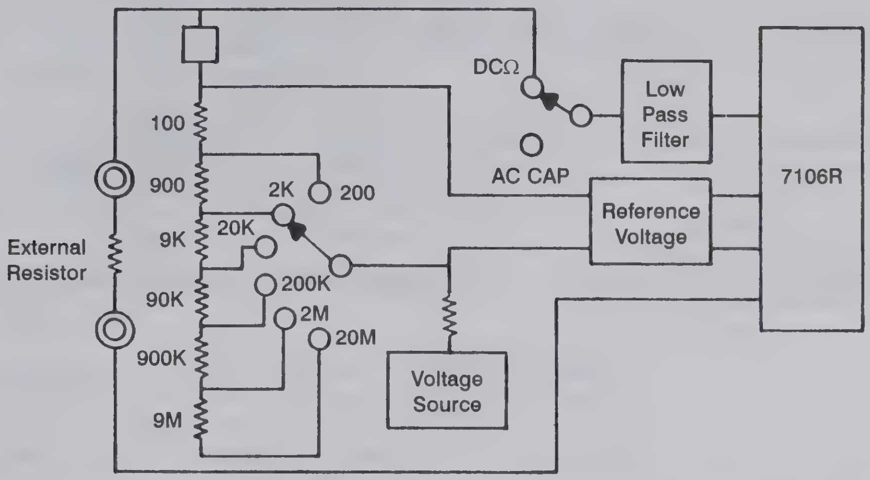
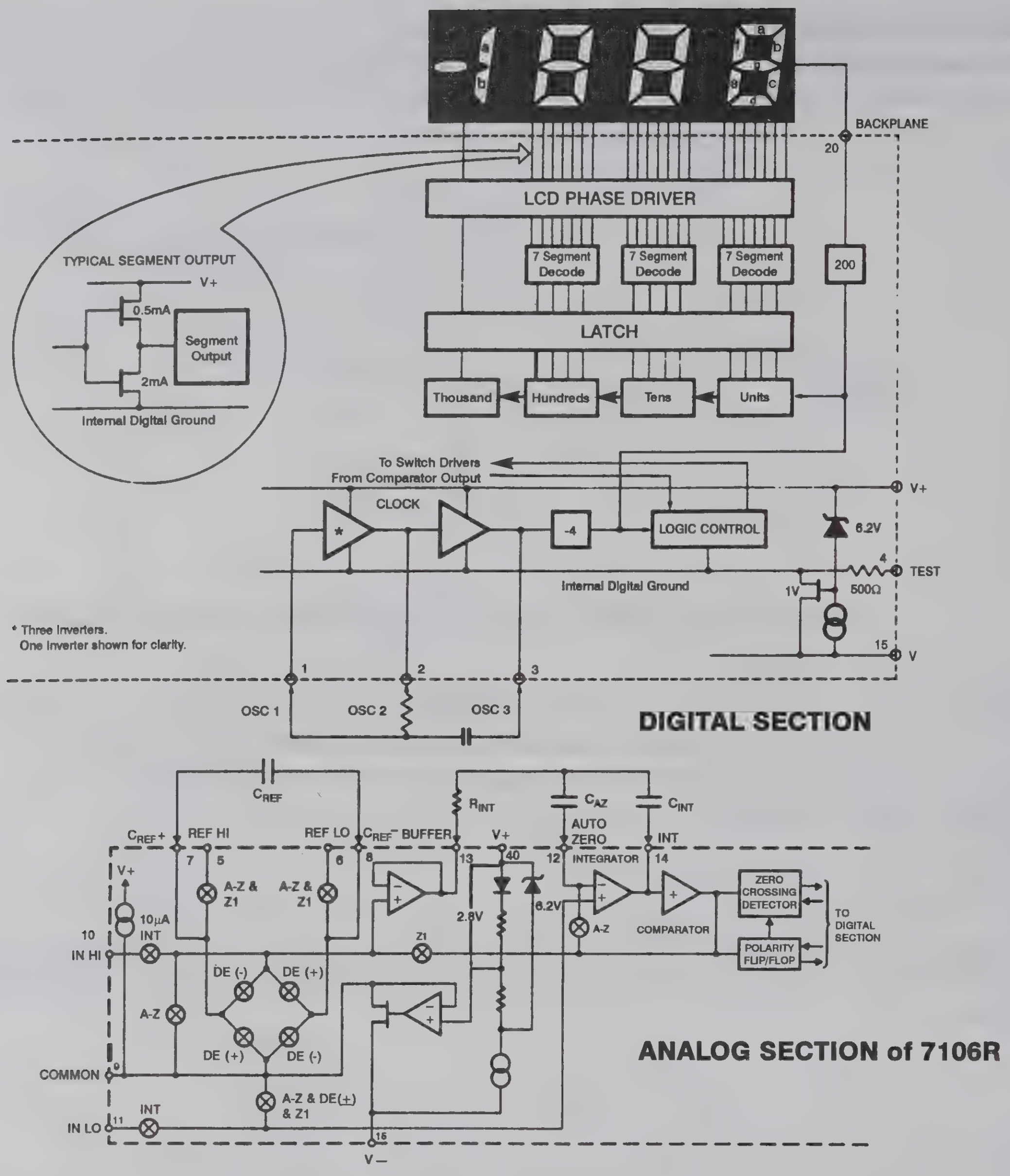

DCΩ
Low Pass Filter
7106R
100
900
2K
200
AC CAP
Reference Voltage
External Resistor
9K
20K
200K
90K
2M
20M
900K
Voltage Source
9M

Figure 5 Simplified Resistance Measurement Diagram

A simple series circuit is formed by the voltage source, a reference resistor from the voltage divider (selected by range switches), and the external unknown resistor. The ratio of the two resistors is equal to the ratio of their respective voltage drops. Therefore, since the value of one resistor is known, the value of the second can be determined by using the voltage drop across the known resistor as a reference. This determination is made directly by the A/D converter.

Overall operation of the A/D converter during a resistance measurement is basically as described earlier in this section, with one exception. The reference voltage present during a voltage measurement is replaced by the voltage drop across the reference resistor. This allows the voltage across the unknown resistor to be read during the read period. As before, the length of the read period is a direct indication of the value of the unknown.

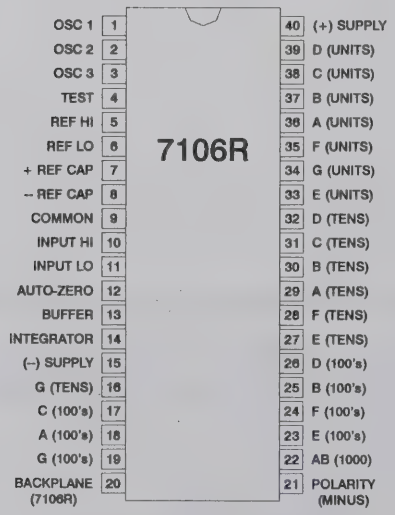

BACKPLANE
20
LCD PHASE DRIVER
7 Segment Decode
7 Segment Decode
7 Segment Decode
200
LATCH
Thousand
Hundreds
Tens
Units
TYPICAL SEGMENT OUTPUT
V+
0.5mA
Segment Output
2mA
Internal Digital Ground
To Switch Drivers
From Comparator Output
CLOCK
÷4
LOGIC CONTROL
V+
6.2V
TEST
4
500Ω
1V
Internal Digital Ground
15
V
* Three inverters.
One inverter shown for clarity.
1
2
3
OSC 1
OSC 2
OSC 3
C_REF
R_INT
C_AZ
C_INT
C_REF+
REF HI
REF LO
C_REF−
BUFFER
V+
AUTO ZERO
INT
7
5
6
8
13
40
12
INTEGRATOR
14
V+
A-Z & Z1
A-Z & Z1
10μA
INT
10
IN HI
Z1
2.8V
6.2V
A-Z
COMPARATOR
ZERO CROSSING DETECTOR
POLARITY FLIP/FLOP
TO DIGITAL SECTION
DE (-)
DE (+)
A-Z
DE (+)
DE (-)
COMMON
9
A-Z & DE(±) & Z1
INT
IN LO
11
15
V−

DIGITAL SECTION

ANALOG SECTION of 7106R

Figure 6 7106R Functions

Pin Configuration


OSC 1 1
OSC 2 2
OSC 3 3
TEST 4
REF HI 5
REF LO 6
+ REF CAP 7
− REF CAP 8
COMMON 9
INPUT HI 10
INPUT LO 11
AUTO-ZERO 12
BUFFER 13
INTEGRATOR 14
(−) SUPPLY 15
G (TENS) 16
C (100's) 17
A (100's) 18
G (100's) 19
BACKPLANE (7106R) 20
7106R
40 (+) SUPPLY
39 D (UNITS)
38 C (UNITS)
37 B (UNITS)
36 A (UNITS)
35 F (UNITS)
34 G (UNITS)
33 E (UNITS)
32 D (TENS)
31 C (TENS)
30 B (TENS)
29 A (TENS)
28 F (TENS)
27 E (TENS)
26 D (100's)
25 B (100's)
24 F (100's)
23 E (100's)
22 AB (1000)
21 POLARITY (MINUS)

7106R Pin Connections

ASSEMBLY

The meter kit has been divided into a number of sections to make the assembly easy and avoid major problems with the meter operation.

OPEN ONLY THOSE COMPONENT BAGS THAT ARE CALLED FOR IN YOUR ASSEMBLY PROCEDURE. DO NOT OPEN ANY OTHER BAGS.

Do not build more than one section of your meter at a time. Your instructor must approve the proper operation of the section you have built before you proceed to the next section. This procedure will minimize the problems you may have at the completion of the project.

Your kit program is divided into Sections “A through F”. The small parts bags will be marked accordingly. The sections are listed below.

Section A - Meter display circuit assembly.

Section B - DC voltage and current circuit assembly.

Section C - AC voltage and current circuit assembly.

Section D - Resistance circuit assembly.

Section E - Capacitance and transistor testing circuit assembly.

Section F - Final assembly.

IMPORTANT CONSTRUCTION NOTES

1. Wash your hands with soap and water before you assemble this kit. The high impedance areas on the circuit board can be contaminated by salt and oil from your skin. If these areas become contaminated, your completed multimeter may not meet the listed specifications. Handle the circuit board only by its edges.

2. Avoid any excessive accumulation of resin build-up whenever you solder a connection.

3. Take your time assembling the circuit board. Work at a slow pace. Remember that accuracy is far more important than speed.

4. When you perform the steps in assembly, identify each respective component before you install it. Then position it over its outline on the top legend side of the PC board, unless otherwise indicated.

5. Check for the proper polarity of ICs, diodes, electrolytic capacitors, battery snap and LCD.

CONSTRUCTION

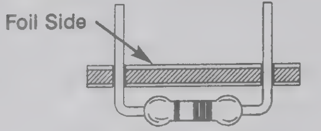
Introduction

Assembly of your M-2665K Digital Multimeter Kit will prove to be an exciting project and give you much satisfaction and personal achievement. If you have experience in soldering and wiring techniques, then you should have no problem with the assembly of this kit. Care must be given to identifying the proper components and in good soldering habits. Above all, take your time and follow these easy step-by-step instructions. Remember, "An ounce of prevention is worth a pound of cure". Avoid making mistakes and no problems will occur.

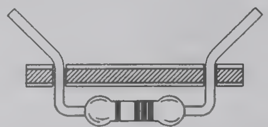
CAUTION: WEAR SAFETY GLASSES WHEN ASSEMBLING THIS KIT.

Assemble Components

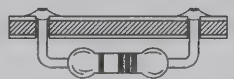
In all of the following assembly steps, the components must be installed on the top side of the PC board unless otherwise indicated. The top legend shows where each component goes. The leads pass through the corresponding holes and the board is turned to solder the component leads on the foil side. Solder immediately unless the pad is adjacent to another hole which will interfere with the placement of the other component. Cut excessive leads with a diagonal cutter. Then, place a check mark in the box provided next to each step to indicate that the step is completed. Be sure to save the extra leads for use as jumper wires if needed.



Mount Part



Bend Leads to Hold Part



Solder and Cut Off Leads

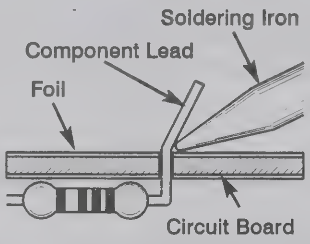
☑ Rx - 100Ω 5% 1/4W Resistor
(brown-black-brown-gold)

Soldering

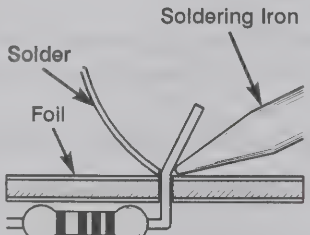
The most important factor in assembling your digital multimeter is good soldering techniques. Using the proper soldering iron is of prime importance. A small pencil type soldering iron of 25 - 40 watts is recommended. **The tip of the iron must be kept clean at all times and well tinned.** Many areas on the PC board are close together and care must be given not to form a solder bridge (Example 2). Size and care of the tip will eliminate problems.

For a good soldering job, the areas being soldered must be heated sufficiently so that the solder flows freely (1). Apply the solder simultaneously to the component lead and the component pad on the PC board (2) so that good solder flow will occur (3). Be sure that the lead extends through the solder smoothly indicating a good solder joint (4). **Use only rosin core solder of 60/40 alloy. DO NOT USE ACID CORE SOLDER!** Do not blob the solder over the lead because this can result in a cold solder joint.

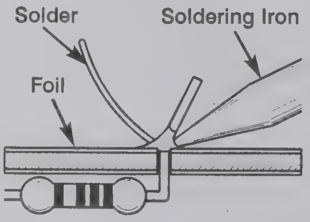
1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.



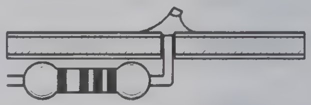
2. First apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.



3. Allow the solder to flow around the connection. Then, remove the solder and the iron and let the connection cool. The solder should have flowed smoothly and not lump around the wire lead.



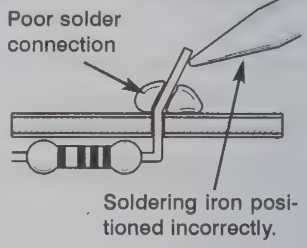
4. Here is what a good solder connection looks like. Cut off excess leads.



Example 1

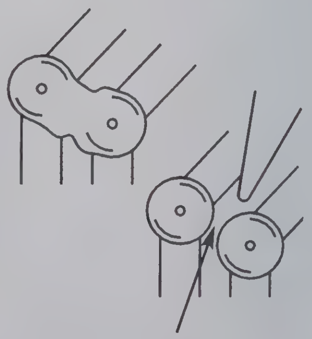
Poor solder connections occur when the lead is not heated sufficiently. The solder will not flow onto the lead as shown. To correct. reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

Solder does not flow onto the lead. A hard rosin bead surrounds and insulates the connection.



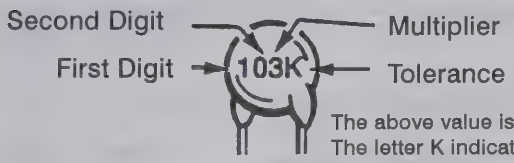
Example 2

A solder bridge occurs when solder runs between circuit paths and creates a short circuit. This is usually caused by using too much solder. To correct this, simply drag your soldering iron across the solder bridge as shown.



IDENTIFYING CAPACITOR VALUES

Capacitors will be identified by their capacitance value in pF (picofarads) or µF (microfarads). Most capacitors will have their actual value printed on them. Some capacitors may have their value printed in the following manner.



Multiplier	For the No.	0	1	2	3	4	5	8	9
	Multiply By	1	10	100	1K	10K	100K	.01	0.1

The above value is 10 x 1,000 = 10,000pF or .01µF
The letter K indicates a tolerance of ±10%
The letter J indicates a tolerance of ±5%

Note: The letter "R" may be used at times to signify a decimal point; as in 3R3 = 3.3

IDENTIFYING RESISTOR VALUES

Use the following information as a guide in properly identifying the value of resistors.

BAND 1
1st Digit

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 2
2nd Digit

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 3 **(If used)**
3rd Digit

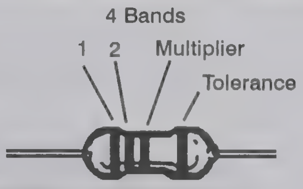
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

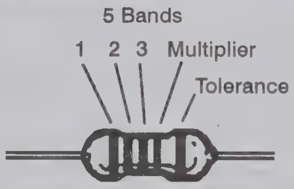
Multiplier

Color	Multiplier
Black	1
Brown	10
Red	100
Orange	1,000
Yellow	10,000
Green	100,000
Blue	1,000,000
Silver	0.01
Gold	0.1

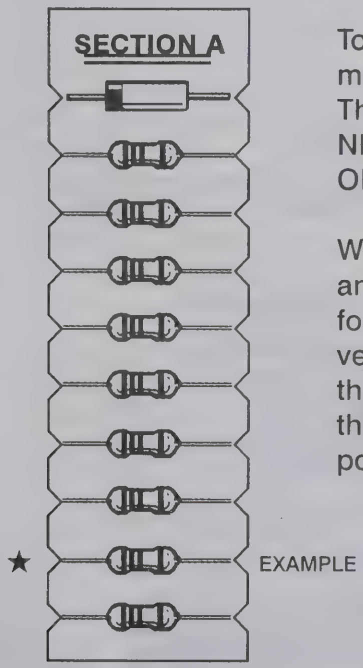
Resistance Tolerance

Color	Tolerance
Silver	±10%
Gold	±5%
Brown	±1%
Red	±2%
Orange	±3%
Green	±.5%
Blue	±.25%
Violet	±.1%





PART IDENTIFICATION CARDS



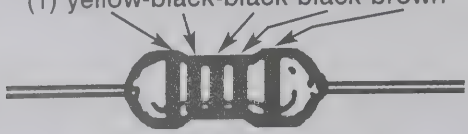
To help identify the resistors and diodes used in the construction of your digital multimeter we have mounted the diodes and resistors of each section onto a card. The card will help you find the diodes and resistors quickly. THE PARTS WILL NOT NECESSARILY BE LISTED IN THE ORDER SHOWN IN THE PARTS LIST SECTION OR IN THE ASSEMBLY PROCEDURE.

When you are ready to assemble the meter kit, follow the procedure shown. For an example refer to page 11 for assembly of Section "A". The first resistor called for is R-20, 110KΩ resistor (brown-brown-yellow-gold). Locate it on the card (★), verify that it is the correct value. Some resistors may be mounted backwards on the card so you must be certain that you are reading the resistors correctly. When the correct value has been established, only then will you mount it into its correct position on the PC board.

RESISTOR READING EXERCISE

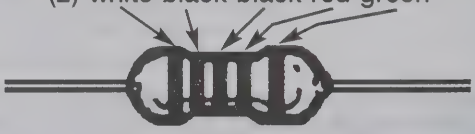
Before starting assembly of your digital multimeter project, you should be thoroughly familiar with the 5 band color code system. Many of the resistor values will be identified by color bands and it is easy to mistake their value if you read the colors incorrectly or read the value from the wrong end. Do the following exercise in resistor values. Place your answer in the box beneath the resistor. Answers are on the bottom of this page.

(1) yellow-black-black-black-brown



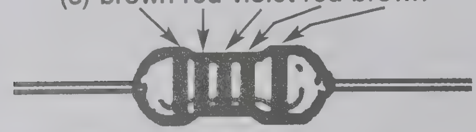
400Ω 1%

(2) white-black-black-red-green



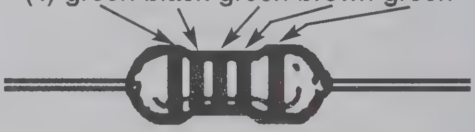
90K -.5%

(3) brown-red-violet-red-brown



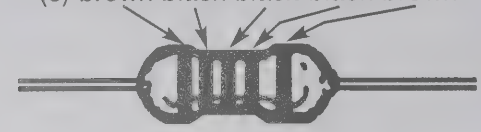
12.7K 1%

(4) green-black-green-brown-green



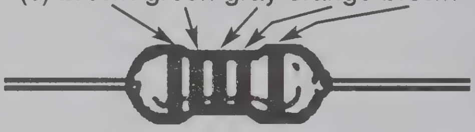
.05K .5%

(5) brown-black-black-black-brown



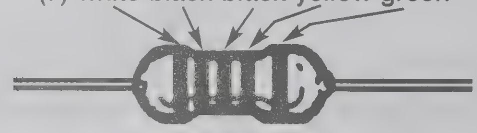
100Ω 1%

(6) brown-green-gray-orange-brown



158K-1%

(7) white-black-black-yellow-green

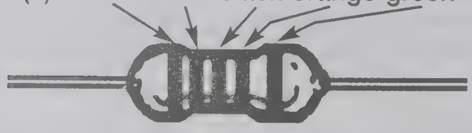


9MΩ .5%

(8) white-black-black-silver-green

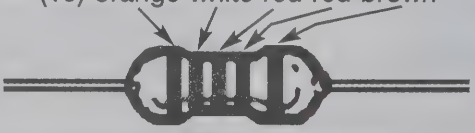
9Ω-.5%

(9) brown-black-black-orange-green



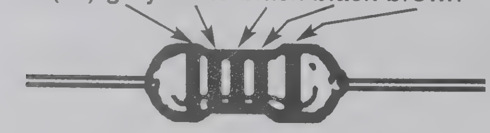
100 KΩ .5%

(10) orange-white-red-red-brown



39.2K-1%

(11) gray-white-black-black-brown



890Ω 1%

(12) brown-brown-black-red-brown

11 KΩ-1%

Answers to Resistor Reading Exercise: 1) 400Ω±1%; 2) 90KΩ±.5%; 3) 12.7KΩ±1%; 4) 5.05KΩ±.5%; 5) 100Ω±1%; 6) 158KΩ±1%; 7) 9MΩ±.5%; 8) 9Ω±.5%; 9) 100KΩ±.5%; 10) 39.2KΩ±1%; 11) 890Ω±1%; 12) 11KΩ±1%;

SECTION A

Meter Display Circuit

PARTS LIST - SECTION A

RESISTORS

Qty	Symbol	Description	Color Code	Part #
☑ 1	R24	56KΩ 5% 1/4W	green-blue-orange-gold	155600
☑ 1	R19	100KΩ 5% 1/4W	brown-black-yellow-gold	161000
☑ 1	R20	110KΩ 5% 1/4W	brown-brown-yellow-gold	161100
☑ 6	R16, 17, 18, 21, 22, 23	1MΩ 5% 1/4W	brown-black-green-gold	171000

Note: Resistor tolerance (last band) of 5-band resistors may be green instead of brown.

CAPACITORS

Qty	Symbol	Value	Description	Part #
☑ 1	C2	100pF (101)	Ceramic Capacitor	221017
☑ 1	C3	.047μF (473)	Mylar Capacitor	244717
☑ 1	C4	.1μF (104)	Mylar Capacitor	251017
☑ 2	C5, C6	.22μF (224)	Mylar Capacitor	252217

SEMICONDUCTORS

Qty	Symbol	Value	Description	Part #
☑ 1	ZD	1N5232/1N752	Zener Diode	315232
☑ 1	U2	4030/4070	Integrated Circuit	334030
☑ 1	U1	7106R	Integrated Circuit	337106R

MISCELLANEOUS

Qty	Description	Part #	Qty	Description	Part #
☑ 1	Liquid Crystal Display (LCD)	35114A	☑ 1	LCD Stopper	629005
☑ 1	Zebra	500000	☑ 1	LCD Housing	629007
☑ 1	PC Board	516000A	☑ 2	M2.3 x 6 Screw	642360
☑ 1	Solder Roll	551135	* ☐ 1	M2.3 x 8 Screw	642430
☑ 1	Battery Snap (BAT)	590098	☑ 1	40-Pin IC Socket	664040
☑ 1	Battery	590009	* ☑ 6	Slide Contact	680016
☑ 1	LCD Window Plate	621002A	☑ 1	Top Plate (A)	724001A
* ☑ 1	Range Selector Knob	622003	☑ 1	Manual (M-2665K)	753005
* ☑ 1	Bushing	624004	☑ 2	Shims	780006

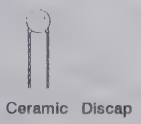
* Parts installed on PC board already.

PARTS IDENTIFICATION

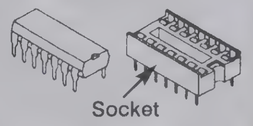
Resistor

Diode

Capacitor

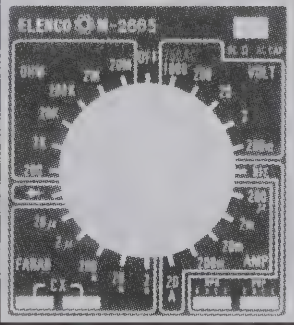


Integrated Circuit

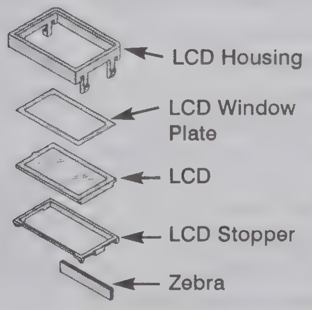


Battery Snap

Top Plate (A)



Liquid Crystal Display (LCD)



ASSEMBLE THE FOLLOWING COMPONENTS TO THE PC BOARD

In all of the following steps **the components must be installed on the top legend side of the PC board. The board is turned to solder the component leads on the selector switch side.**

Figure A

Align the notch on the socket (if any) with the notch marked on the PC board. Solder the socket to the PC board. Insert the IC into the socket with the notch as shown below. **Note: If the IC is already inserted into the socket, do not attempt to pull it out, as this will damage the IC and socket. Instead, solder the socket to the PC board with the IC in it.**

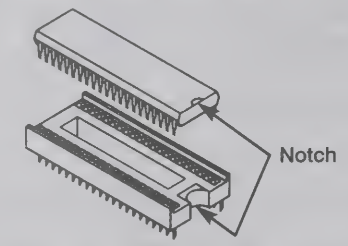


Figure B

Lay resistor flat against the PC board.

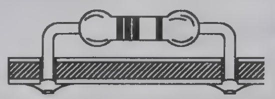
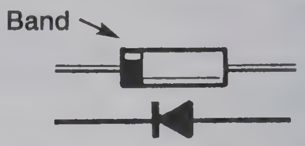


Figure C

Mount the diodes with the band in the correct direction as shown on the top legend.



☐ U1 - 40 Pin IC Socket
☐ U1 - 7106 IC
(see Figure A)

☐ R20 - 110KΩ 5% 1/4W Res.
(brown-brown-yellow-gold)
(see Figure B)

☐ C2 - 100pF (101) Ceramic Cap.
(see Figure D)

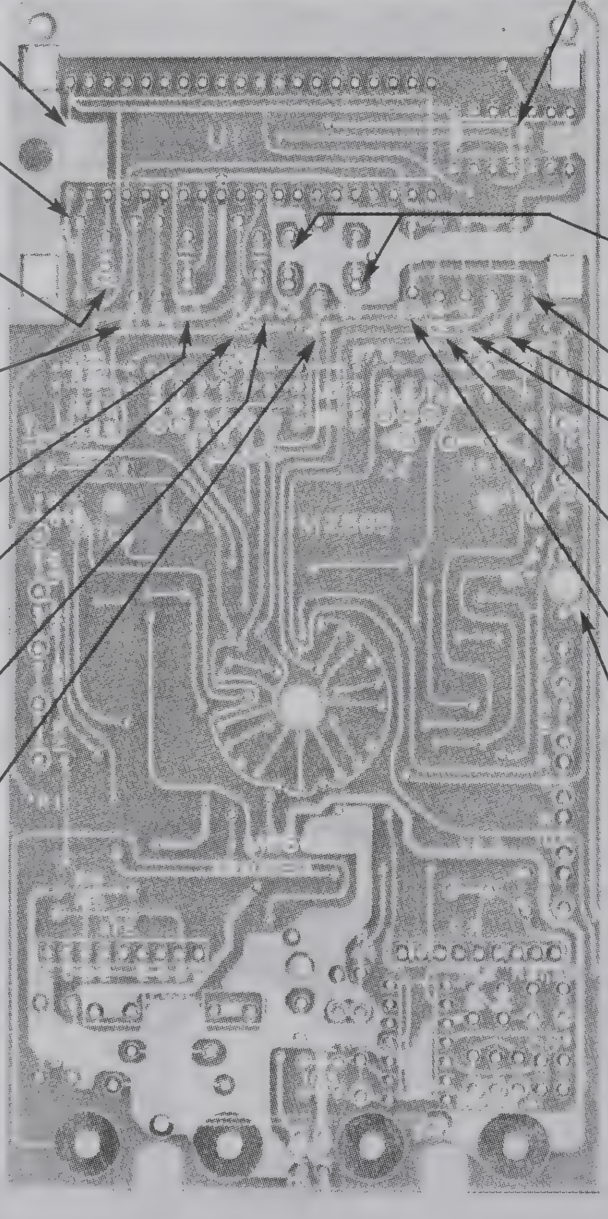
☐ R21 - 1MΩ 5% 1/4W Res.
☐ R22 - 1MΩ 5% 1/4W Res.
(brown-black-green-gold)
(see Figure B)

☐ C3 - .047μF (473) Mylar Cap.
(see Figure D)

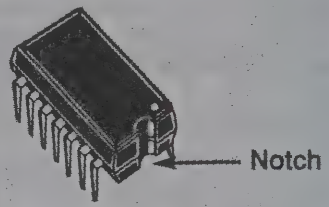
☐ R23 - 1MΩ 5% 1/4W Res.
(brown-black-green-gold)
(see Figure B)

☐ C4 - .1μF (104) Mylar Cap.
(may be marked 104)
(see Figure D)

☐ R24 - 56KΩ 5% 1/4W Res.
(green-blue-orange-gold)
(see Figure B)



☐ U2 - 4030 IC or 4070
No IC socket used



Solder the IC to the PC board with the notch in the direction shown on the top legend.

☐ C5 - .22μF (224) Mylar Cap
☐ C6 - .22μF (224) Mylar Cap.
(see Figure D)

☐ R16 - 1MΩ 5% 1/4W Res.
☐ R18 - 1MΩ 5% 1/4W Res.
☐ R17 - 1MΩ 5% 1/4W Res.
(brown-black-green-gold)
(see Figure B)

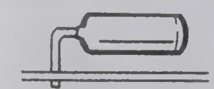
☐ R19 - 100KΩ 5% 1/4W Res.
(brown-black-yellow-gold)
(see Figure B)

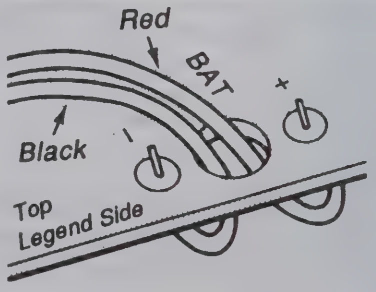
☐ ZD - 1N5232 Diode
(see Figure C)

☐ BAT - Battery Snap
Insert both wires through the hole and mount the red wire to the (+) hole and the black wire to the (–) hole. Solder the wires from the top legend side.

Figure D

Mount the capacitors with 1/4" of space between the body and the PC board. Bend cap over as shown.





ASSEMBLE THE LCD

☐ Assemble the LCD into the housing with the parts shown in Figure E. The LCD must be put in with the notch in the direction shown in Figure E. Peel off the clear protective film on top of the LCD (see Figure G), then place the LCD plate into the housing with the two curved corners on the inside of the plate in the same direction as the two curved corners on the housing. Wipe off zebra edges with a lint-free cloth.

☐ Mount the LCD unit to the PC board. Insert the two pins on the side shown in Figure E into the holes on the PC board. Then push the other end down until it snaps into place.

☐ Screw the LCD housing to the PC board with two M2.3 x 6 screws as shown in Figure E.

Testing Procedure

Placing the top plate (A) over the knob will assist in obtaining the correct knob position when doing tests.

Connect the 9V battery and turn the range selector. The LCD will display random numbers. As you turn the knob clockwise, the decimal point will move also. Check that all of the segments that make up the certain number are displayed. If the LCD is working correctly, move the knob to the off position and remove the battery. If the tests are not working, check for cold solder joints, part values and if the LCD is assembled correctly. **DO NOT PROCEED TO SECTION B WITHOUT INSTRUCTOR'S APPROVAL.**

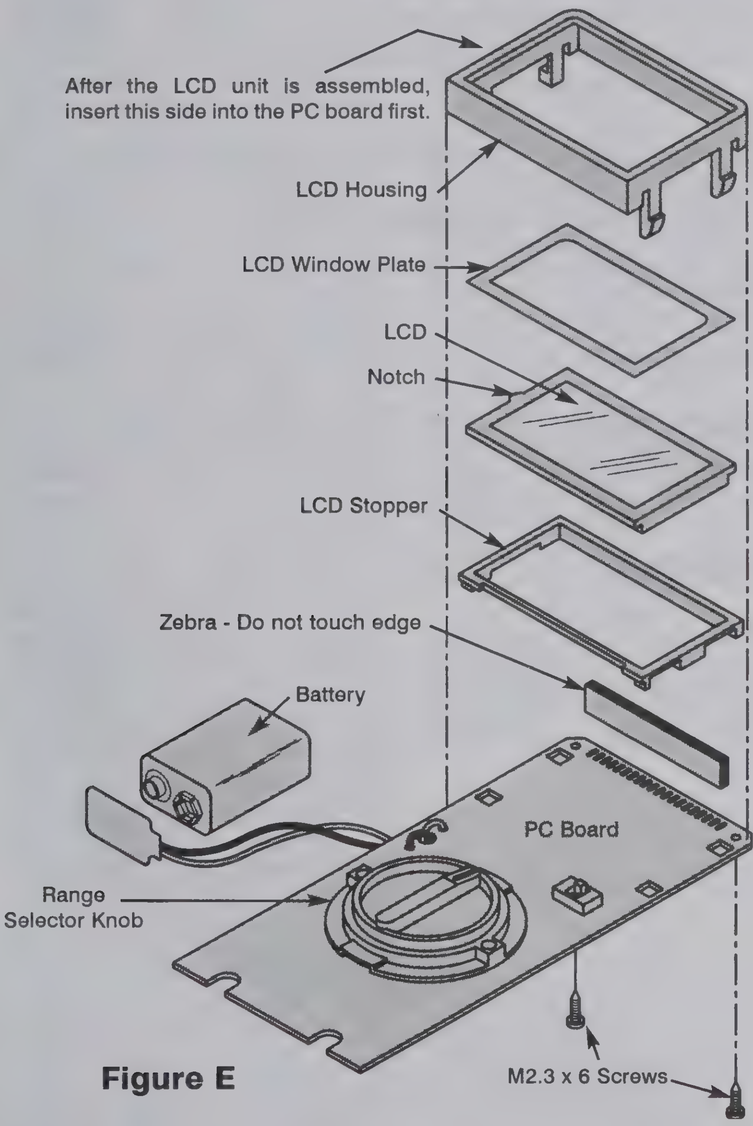

After the LCD unit is assembled, insert this side into the PC board first.
LCD Housing
LCD Window Plate
LCD
Notch
LCD Stopper
Zebra - Do not touch edge
Battery
PC Board
Range Selector Knob
M2.3 x 6 Screws

Figure E

NOTE: If the range selector switch becomes hard to turn, then loosen the M2.3 x 8 screw slightly.

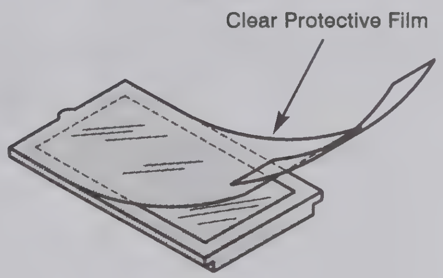

Clear Protective Film

Figure F

SECTION B

DC Voltage & Current Circuit

PARTS LIST - SECTION B

RESISTORS

Qty	Symbol	Description	Color Code	Part #
☐ 1	R13	1Ω .5% 1/2W	brown-black-gold-green	111051
☐ 1	R12	9Ω .5% 1/4W	white-black-black-silver-green	119050
☐ 1	R6	100Ω .5% 1/4W	brown-black-black-black-green	131050
☐ 1	R5	900Ω .5% 1/4W	white-black-black-black-green	139050
☐ 1	R28	1.3KΩ 1% 1/4W	brown-orange-black-brown-brown	141230
☐ 1	R27	2KΩ 1% 1/4W	red-black-black-brown-brown	142030
☐ 1	R46	5.6KΩ 5% 1/4W	green-blue-red-gold	145600
☐ 1	R26	8.2KΩ 5% 1/4W	gray-red-red-gold	148200
☐ 1	R4	9KΩ .5% 1/4W	white-black-black-brown-green	149050
☐ 1	R25	39.2KΩ 1% 1/4W	orange-white-red-red-brown	153930
☐ 1	R3	90KΩ .5% 1/4W	white-black-black-red-green	159050
☐ 1	R2	900KΩ .5% 1/4W	white-black-black-orange-green	169050
☐ 1	R1	9MΩ .5% 1/2W	white-black-black-yellow-green	179051
☐ 1	VR1	200Ω	Potentiometer	191320

★ **Note:** Some resistors may not have a color coding, but they will have the value imprinted on them.

Note: Resistor tolerance (last band) of 5-band resistors may be green instead of brown.

CAPACITORS

Qty	Symbol	Value	Description	Part #
☐ 1	C1	22μF	Electrolytic (Lytic)	272244

SEMICONDUCTORS

Qty	Symbol	Value	Description	Part #
☐ 2	D1, D2	1N4001	Diode	314001

MISCELLANEOUS

Qty	Symbol	Description	Part #
☐ 1		Shunt Wire M1.6 x 60	100069
☐ 1		Fuse 2A	533020
* ☐ 1	SW1	Slide Switch	541104
☐ 1		Slide Switch Knob	622004
☐ 2		Fuse Holder	663003
☐ 4		Input Socket	664000
☐ 1		Test Lead Set	RWTL14

* Part installed on PC board already

ASSEMBLE THE FOLLOWING COMPONENTS TO THE PC BOARD

In all of the following steps **the components must be installed on the top legend side of the PC board. The board is turned to solder the component leads on the selector switch side.**

Figure G

Stand resistor on end as shown with the body inside the white circle.

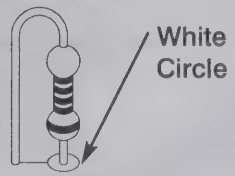
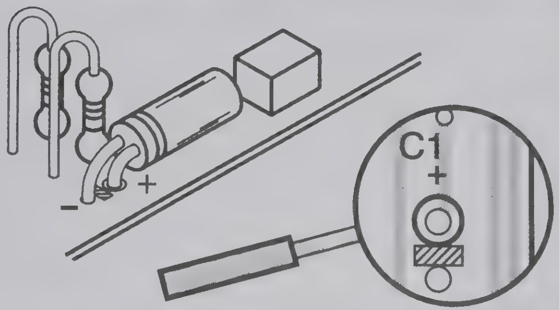


Figure H

Lytics have a polarity marking on them indicating the negative lead, the opposite lead is positive. The PC board is marked to show the positive (+) lead position. Mount the capacitor with the positive (+) lead in the hole marked on the PC board. Bend the capacitor over.



☐ R6 - 100Ω .5% 1/4W Res.
(brown-blk-blk-blk-green)
(see Figure G)

☐ R5 - 900Ω .5% 1/4W Res.
(white-blk-blk-blk-green)
(see Figure G)

☐ R4 - 9KΩ .5% 1/4W Res.
(white-blk-blk-brown-green)
(see Figure G)

☐ R3 - 90KΩ .5% 1/4W Res.
(white-blk-blk-red-green)
(see Figure G)

☐ R2 - 900KΩ .5% 1/4W Res.
(white-blk-blk-orange-green)
(see Figure G)

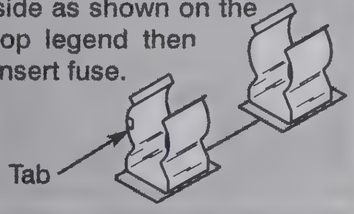
☐ R1 - 9MΩ .5% 1/2W Res.
(white-blk-blk-yellow-green)
(see Figure B)

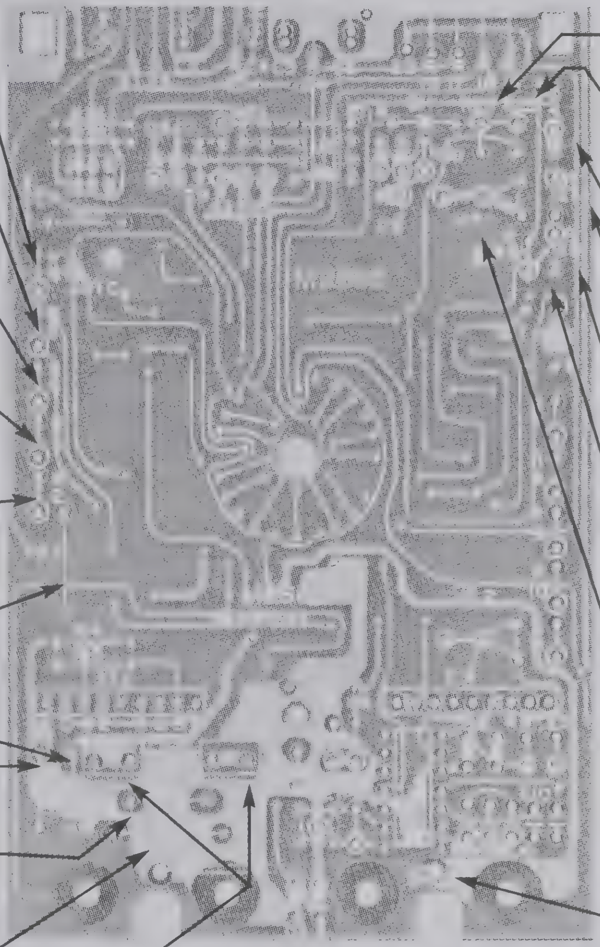
☐ D1 - 1N4001 Diode
☐ D2 - 1N4001 Diode
(see Figure C)

☐ R12 - 9Ω .5% 1/4W Res.
(white-blk-blk-silver-green)
(see Figure B)

☐ R13 - 1Ω .5% 1/2W Res.
(brown-black-gold-green)
(see Figure B)

☐ Fuse Holders
☐ Fuse 2A
Mount holders with the tab side as shown on the top legend then insert fuse.





☐ R26 - 8.2KΩ 5% 1/4W Res.
(gray-red-red-gold)
(see Figure G)

☐ R25 - 39.2KΩ 1% 1/4W Res.
(orange-white-red-red-brown)
(see Figure G)

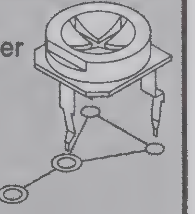
☐ C1 - 22μF Lytic Capacitor
(see Figure H)

☐ R27 - 2KΩ 1% 1/4W Res.
(red-blk-blk-brown-brown)
(see Figure G)

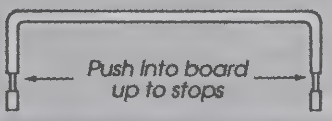
☐ R28 - 1.3KΩ 1% 1/4W Res.
(brn-orange-blk-brn-brn)
(see Figure G)

☐ R46 - 5.6KΩ 5% 1/4W Res.
(green-blue-red-gold)
(see Figure G)

☐ VR1 - 200Ω
Potentiometer



☐ Shunt



☐ Push the four input sockets into the PC board holes from the selector switch side until they stop (see Figure I). Turn the board over as shown in Figure Ia and solder the sockets in place from the top legend side. Apply enough heat to allow the solder to flow around the input sockets (see Figure Ib).

☐ Push on the slide switch knob.

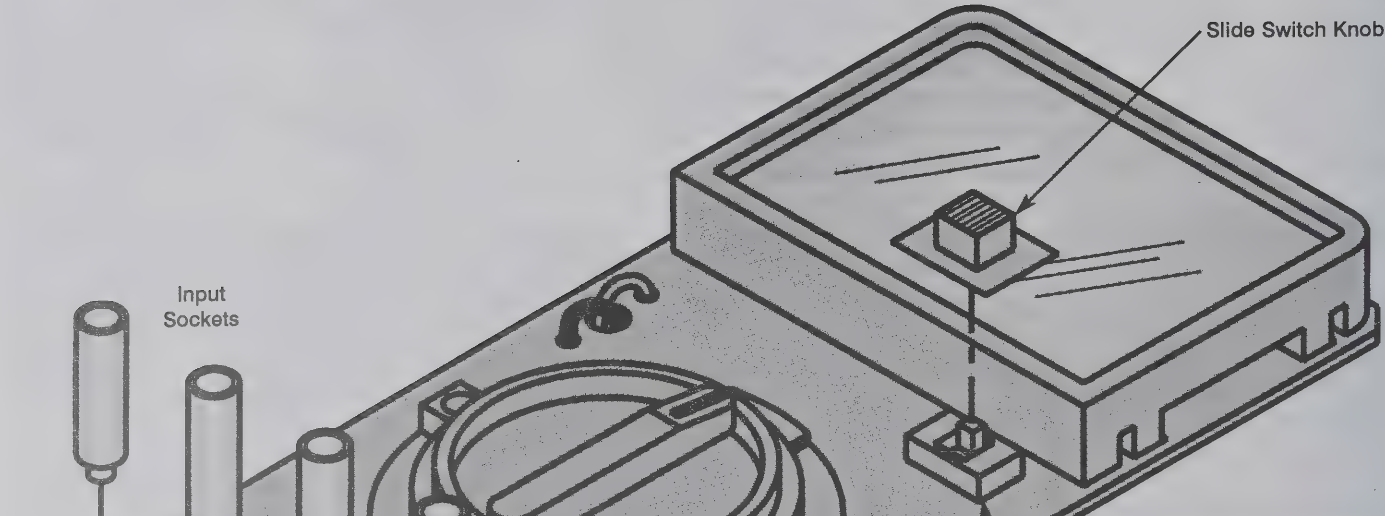


Figure I

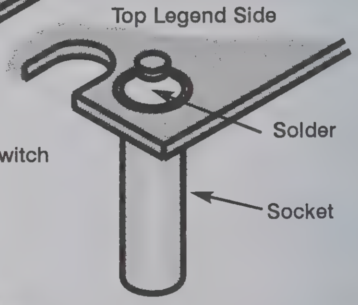


Figure Ib

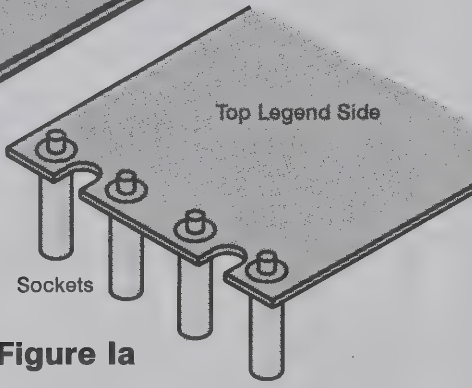


Figure Ia

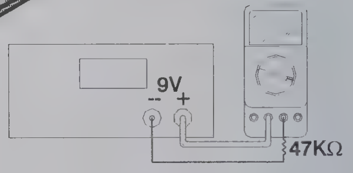


Figure Ic

Testing Procedure

Voltage Test

Connect the 9V battery to the meter. Turn the range selector knob to the 20V position and connect the test leads (red lead to VΩ and black to COM), see Figure Ic. Using another meter of known accuracy, measure a DC voltage less than 20V (such as a 9 volt battery). You will calibrate the kit meter by measuring the same voltage source and adjusting VR1 until the kit meter reads the same as the accurate meter. When the two meters agree, the voltage circuit is calibrated. Turn the range selector knob to the off position.

Current Test

Connect the kit meter and another meter of known accuracy in series. Set the meters in the 200μA position. Construct a circuit for a DC current (for example 9V and a 47KΩ resistor for 190μA) and measure the circuit. Both meters should have close to the same readings. If the meters do not agree, check the parts just added. Do not readjust VR1 for this will change the voltage reading set in step 1. Check that 200μA - 200mA scales. The 20A scale requires a circuit of 1 - 10 amps. If the tests are not working, check for cold solder joints and part values. Turn the meter off and remove the battery and test leads. **DO NOT PROCEED TO SECTION C WITHOUT YOUR INSTRUCTOR'S APPROVAL.**

SECTION C

AC Voltage & Current Circuit

PARTS LIST - SECTION C

RESISTORS

Qty	Symbol	Description	Color Code	Part #
☐ 1	R31	5.05KΩ .5% 1/4W	green-black-green-brown-green	145050
☐ 1	R33	5.6KΩ 5% 1/4W	green-blue-red-gold	145600
☐ 2	R35, 36	5.62KΩ .5% 1/4W	green-blue-red-brown-green	145650
☐ 1	R29	10KΩ 5% 1/4W	brown-black-orange-gold	151000
☐ 1	R32	200KΩ 5% 1/4W	red-black-yellow-gold	162000
☐ 1	R34	390KΩ 5% 1/4W	orange-white-yellow-gold	163900
☐ 1	R30	2.2MΩ 5% 1/4W	red-red-green-gold	172200

Note: Resistor tolerance (last band) of 5-band resistors may be green instead of brown.

CAPACITORS

☐ 1	C9	.1μF (104)	Ceramic	251010
☐ 1	C7	.1μF (104)	Mylar	251017
☐ 1	C8	22μF	Electrolytic (Lytic)	272244

SEMICONDUCTORS

☐ 4	D7 - D10	1N4148	Diode	314148
☐ 1	U3	358	Integrated Circuit	330358

MISCELLANEOUS

☐ 1	U3	IC Socket 8-pin		664008

ASSEMBLE THE FOLLOWING COMPONENTS TO THE PC BOARD

In all of the following steps **the components must be installed on the top legend side of the PC board. The board is turned to solder the component leads on the selector switch side.**

☐ D9 - 1N4148 Diode
☐ D10 - 1N4148 Diode
(see Figure J)

☐ R35 - 5.62KΩ .5% 1/4W Res.
☐ R36 - 5.62KΩ .5% 1/4W Res.
(green-blue-red-brn-green)
(see Figure B)

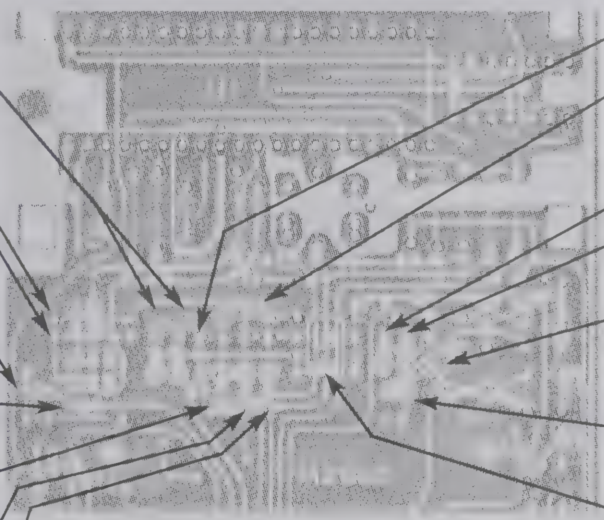
☐ C7 - .1μF (104) Mylar Cap.

☐ R29 - 10KΩ 5% 1/4W Res.
(brown-black-orange-gold)
(see Figure B)

☐ R34 - 390KΩ 5% 1/4W Res.
(orange-white-yellow-gold)
(see Figure G)

☐ R32 - 200KΩ 5% 1/4W Res.
(red-black-yellow-gold)
(see Figure G)

☐ R31 - 5.05KΩ .5% 1/4W Res.
(green-blk-green-brn-green)
(see Figure G)



☐ C9 - .1μF (104) Ceramic Cap.

☐ R33 - 5.6KΩ 5% 1/4W Res.
(green-blue-red-gold)
(see Figure G)

☐ D7 - 1N4148 Diode
☐ D8 - 1N4148 Diode
(see Figure H)

☐ R30 - 2.2MΩ 5% 1/4W Res.
(red-red-green-gold)
(see Figure G)

☐ C8 - 22μF Lytic Capacitor
(see Figure K)

☐ U3 - 8-pin IC Socket
☐ U3 - 358 Integrated Circuit
Align the notch on the socket (if any) with the notch marked on the PC board. Solder the socket to the PC board. Insert the IC into the socket with the notch as shown below.

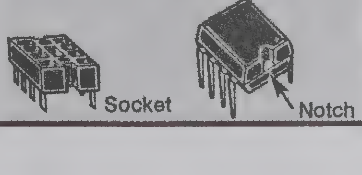


Figure J

Mount diode with the band in the direction of the arrow on the top legend.

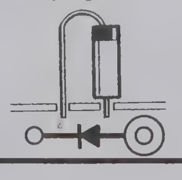
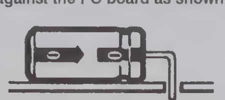


Figure K

Mount the capacitor with the negative (–) lead in the negative hole and the positive (+) lead in the positive hole marked on the PC board. Lay the capacitor flat against the PC board as shown.



SECTION D

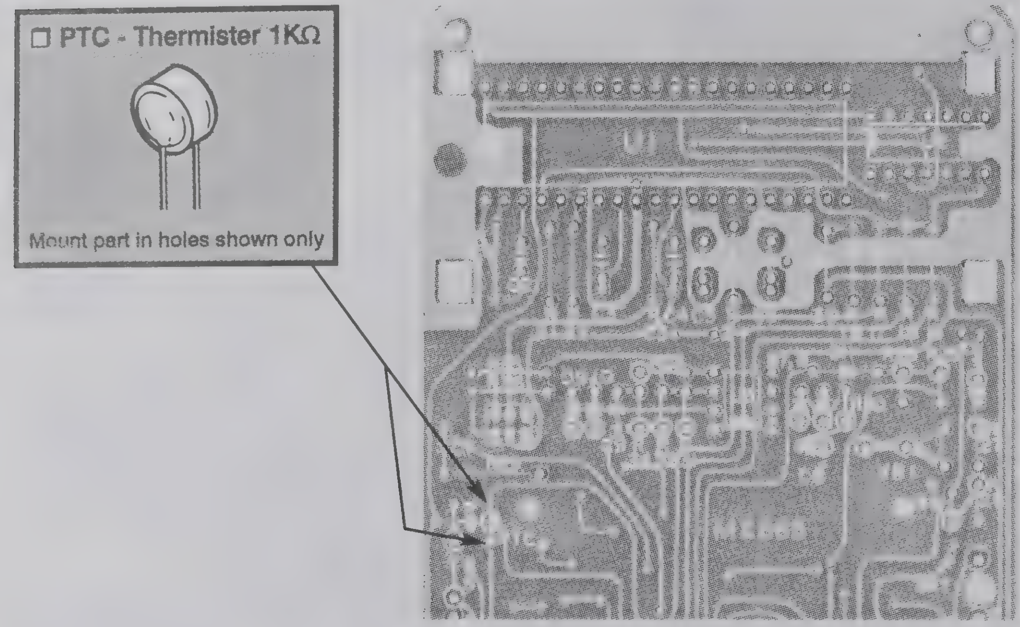
Resistance Circuit

PARTS LIST - SECTION D

Qty	Symbol	Description	Part #
☐ 1	PTC	1KΩ Thermister	190415

ASSEMBLE THE FOLLOWING COMPONENT TO THE PC BOARD

The other components for this section have been installed already.


☐ PTC - Thermister 1KΩ

Mount part in holes shown only

Testing Procedure

Connect the 9V battery and test leads to the meter (red to VΩ and black to COM). Set the range selector knob to one of the Ohm scales. Make sure that SW1 is in the DC/Ohm position. Using two or three different value resistors, check each scale. Compare the kit meter readings with another meter of known accuracy. If the tests are not working, check for cold solder joints, part values, and the contacts on the selector knob to make sure that they are intact. Turn the meter off and remove the battery and test leads.

DO NOT PROCEED TO SECTION E WITHOUT INSTRUCTOR'S APPROVAL.

SECTION E

Capacitance and Transistor Testing Circuit

PARTS LIST - SECTION E

RESISTORS

Qty	Symbol	Description	Color Code	Part #
☐ 1	R7	98.8Ω 1% 1/4W	white-gray-gray-gold-brown	129830
☐ 1	R37	150Ω 5% 1/4W	brown-green-brown-gold	131500
☐ 1	R8	900Ω 1% 1/4W	white-black-black-black-brown	139030
☐ 1	R41	1.91KΩ 1% 1/4W	brown-white-brown-brown-brown	141930
☐ 1	R40	4.12KΩ 1% 1/4W	yellow-brown-red-brown-brown	144130
☐ 1	R9	9KΩ 1% 1/4W	white-black-black-brown-brown	149030
☐ 1	R38	10KΩ 1% 1/4W	brown-black-black-red-brown	151030
☐ 1	R43	11KΩ 1% 1/4W	brown-brown-black-red-brown	151130
☐ 2	R39, R42	39.2KΩ 1% 1/4W	orange-white-red-red-brown	153930
☐ 1	R44	76.8KΩ 1% 1/4W	violet-blue-gray-red-brown	157630
☐ 1	R10	90KΩ 1% 1/4W	white-black-black-red-brown	159030
☐ 1	R45	158KΩ 1% 1/4W	brown-green-gray-orange-brown	161530
☐ 2	R14, R15	240KΩ 5% 1/4W	red-yellow-yellow-gold	162400
☐ 1	R11	909KΩ 1% 1/4W	white-black-white-orange-brown	169060
☐ 1	VR2	200Ω	Potentiometer	191320

Note: Resistor tolerance (last band) of 5-band resistors may be green instead of brown.

CAPACITORS

Qty	Symbol	Value	Description	Part #
☐ 4	C10 - C13	.01μF (103)	Mylar	241017

SEMICONDUCTORS

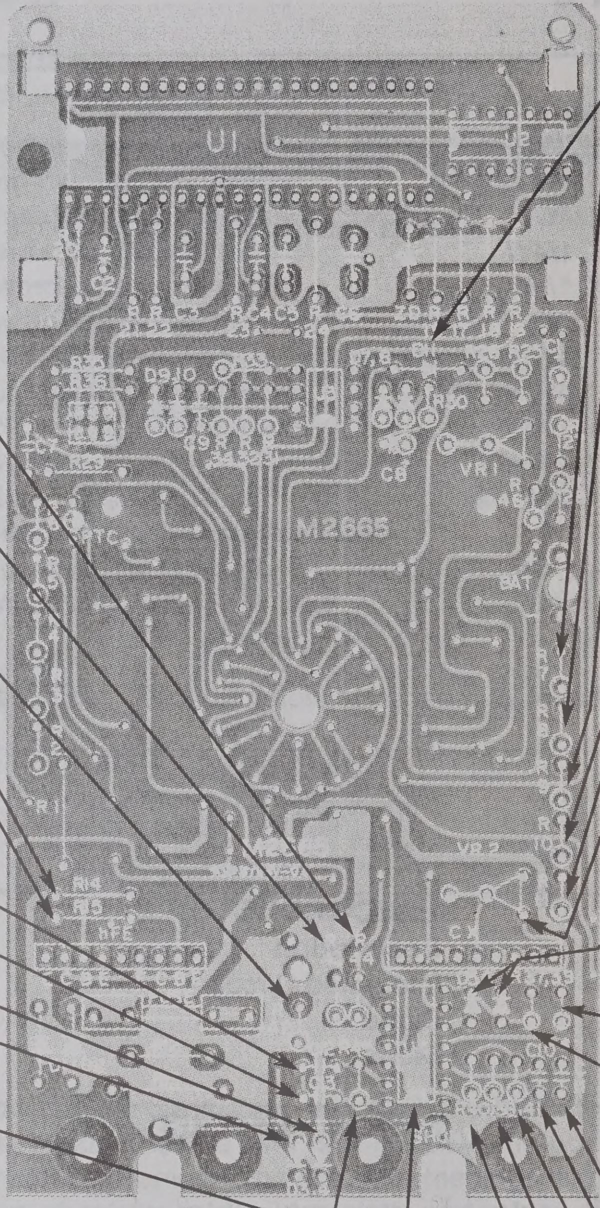
Qty	Symbol	Value	Description	Part #
☐ 1	U4	324 / 17324	Integrated Circuit	330324
☐ 4	D3 - D6	1N4001	Diode	314001
☐ 1	D11	1N4148	Diode	314148

MISCELLANEOUS

Qty	Symbol	Description	Part #
☐ 2	h_{FE}, CX	9-pin Socket	664009
☐ 1	U4	IC Socket 14-pin	664014

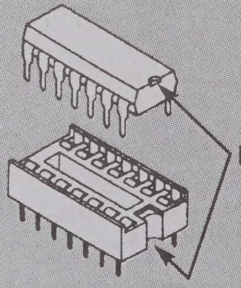
ASSEMBLE THE FOLLOWING COMPONENTS TO THE PC BOARD

In all of the following steps **the components must be installed on the top legend side of the PC board. The board is turned to solder the component leads on the selector switch side.**



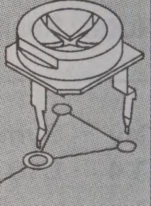
- ☐ R44 - 76.8KΩ 1% 1/4W Res. (violet-blue-gray-red-brown) (see Figure G)
- ☐ R43 - 11KΩ 1% 1/4W Res. (brown-brown-blk-red-brn) (see Figure G)
- ☐ R42 - 39.2KΩ 1% 1/4W Res. (orange-white-red-red-brn) (see Figure G)
- ☐ R14 - 240KΩ 5% 1/4W Res.
- ☐ R15 - 240KΩ 5% 1/4W Res. (red-yellow-yellow-gold) (see Figure B)
- ☐ C12 - .01μF (103) Mylar Cap.
- ☐ C13 - .01μF (103) Mylar Cap.
- ☐ D3 - 1N4001 Diode
- ☐ D4 - 1N4001 Diode (see Figure J)
- ☐ R45 - 158KΩ 1% 1/4W Res. (brown-grn-gray-orange-brn) (see Figure G)

- ☐ U4 - 14-pin IC Socket
- ☐ U4 - 324 Integrated Circuit



Align the notch on the socket (if any) with the notch marked on the PC board. Solder the socket to the PC board. Insert the IC into the socket with the notch as shown below.

- ☐ D11 - 1N4148 Diode (see Figure C)
- ☐ R7 - 98.8Ω 1% 1/4W Res. (wht-gray-gray-gold-brn) (see Figure G)
- ☐ R8 - 900Ω 1% 1/4W Res. (wht-blk-blk-blk-brn) (see Figure G)
- ☐ R9 - 9KΩ 1% 1/4W Res. (wht-blk-blk-brn-brn) (see Figure G)
- ☐ R10 - 90KΩ 1% 1/4W Res. (wht-blk-blk-red-brn) (see Figure G)
- ☐ R11 - 909KΩ 1% 1/4W Res. (wht-blk-wht-org-brn) (see Figure G)
- ☐ VR2 - 200Ω Potentiometer



- ☐ D5 - 1N4001 Diode
- ☐ D6 - 1N4001 Diode (see Figure J)
- ☐ R39 - 39.2KΩ 1% 1/4W Res. (org-wht-red-red-brn) (see Figure G)
- ☐ R37 - 150Ω 5% 1/4W Res. (brn-grn-brn-gold) (see Figure G)
- ☐ C11 - .01μF (103) Mylar Cap.
- ☐ C10 - .01μF (103) Mylar Cap.
- ☐ R41 - 1.91KΩ 1% 1/4W Res. (brn-wht-brn-brn-brn) (see Figure G)
- ☐ R38 - 10KΩ 1% 1/4W Res. (brn-blk-blk-red-brn) (see Figure G)
- ☐ R40 - 4.12KΩ 1% 1/4W Res. (yel-brn-red-brn-brn) (see Figure G)

QUIZ

1. The function of the A/D converter is to . . .
   - ☐ A - convert digital to analog.
   - ☐ B - divide analog signal by 2.
   - ☐ C - convert analog to digital.
   - ☐ D - convert AC to DC.

2. What type of divider network is used for voltage measurements?
   - ☐ A - Divide by 20.
   - ☐ B - Capacitance.
   - ☐ C - Divide by 5.
   - ☐ D - Resistor.

3. When the AC voltage is measured, it is first . . .
   - ☐ A - divided down by 2.
   - ☐ B - converted to DC.
   - ☐ C - coupled to a halfwave rectifier.
   - ☐ D - low voltage.

4. When measuring current, the shunt resistors convert the current to . . .
   - ☐ A - +.190 to --.190.
   - ☐ B - --1.199 to +1.199.
   - ☐ C - --0.099 to +0.099.
   - ☐ D - --199 to +0.199.

5. Which IC drives the LCD?
   - ☐ A - 358.
   - ☐ B - LM324.
   - ☐ C - 7106R.
   - ☐ D - 1N5232.

6. Resistance measurements are made by . . .
   - ☐ A - comparing voltage drops in the unknown resistor and a reference resistor.
   - ☐ B - measuring the current in the unknown resistor.
   - ☐ C - measuring the current in the reference resistor.
   - ☐ D - equalizing the voltage drop in the unknown and reference resistor.

7. Measurement cycles performed by the A/D converter can be divided into what types of time periods?
   - ☐ A - Long, short.
   - ☐ B - Auto zero, integrate, read.
   - ☐ C - Zero, read, interphase.
   - ☐ D - Autozero, read, cycle phase.

8. A resistor with band colors green-black-green-brown-green is what value?
   - ☐ A - 50.5KΩ ± 5%.
   - ☐ B - 5.15KΩ ± 10%.
   - ☐ C - 5.05KΩ ± .5%.
   - ☐ D - 5.05KΩ ± 1%.

9. When checking a transistor, the selector knob should be in the . . .
   - ☐ A - farad position.
   - ☐ B - ohm position.
   - ☐ C - diode position.
   - ☐ D - h_{FE} position.

10. Where do the leads need to be on the meter when measuring 450mA?
    - ☐ A - A20, COM.
    - ☐ B - V, COM.
    - ☐ C - A, A20.
    - ☐ D - A, COM.

Answers: 1. C, 2. D, 3. B, 4. B, 5. C, 6. A, 7. B, 8. D, 9. D, 10. D

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